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World Beater!

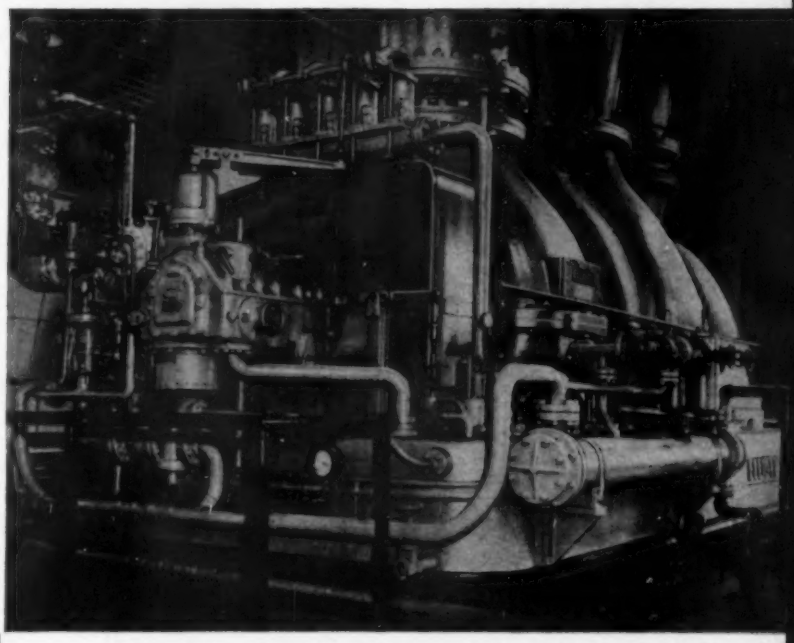
This is the RECORD-BREAKING ELLIOTT BLOWER

that piled up the amazing total of 677 days of continuous operation in the fluid cat cracker of Sunray Oil Corporation, Sunray, Oklahoma — almost two years of non-stop service before the plant was shut down for routine inspection.

This record was a real tribute to the equipment making up the cat cracker unit and to the skill of the refinery operating personnel.

Only one other blower record approaches the above. This one, 610½ days, was also made by an Elliott blower at the refinery of the Tidewater Associated Oil Company, Avon, Calif.

Every detail in the design and construction of these big multi-stage blowers by Elliott is carried out with one basic aim—to provide the long-term performance that brings maximum operating profit.



1200 tons per hour of catalyst are regenerated and circulated by 50,000 inlet cfm of air handled by this big Elliott blower—discharging at 15 psig, and driven by an Elliott 3500-hp turbine at 3740 rpm.

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puts the HEAT on heat exchangers

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VOLUME 30, NO. 6 — JUNE, 1951

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Another Mason-Neilan Basic

In 1944 — The C_v Concept — Universally Used Today

NOW! Point 4 Factor Trim

A thorough study of reduced capacity trim over the past decade has resulted in a new concept of the entire subject, leading to conclusions which are sound from both engineering and manufacturing standpoints and which simplify the problem for the user. Mason-Neilan now offers *Point 4 Factor Trim* based on the following general principles:

1. Since a properly designed wide range control valve will control satisfactorily near its stroke limits, a vast majority of flow problems can be handled by valves with full capacity trim. Therefore, unless the required reduction in capacity is appreciable, no advantage is obtained by the use of reduced capacity trim.

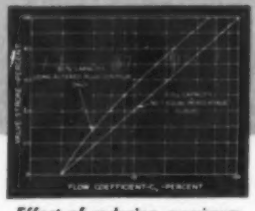
2. The only practical reduced capacity trim design is one which *extends the minimum* controllable flow as well as *reducing the maximum*. A simple analysis shows that to extend the minimum controllable flow it is *necessary to reduce the seat ring diameter.*

3. *Only one reduction* is practical for a given size top-and-bottom guided, double or single seated control valve. The optimum reduction consistent with retention of mechanical strength is approximately 60% of full capacity; hence the capacity of a valve with reduced capacity trim should be .4 of full capacity. The logical description of this trim is therefore—

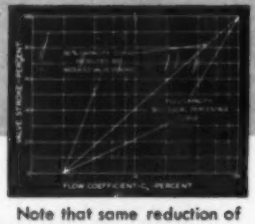
Point 4 Factor Trim

There are a number of valid reasons for specifying reduced capacity trim in control valves for industrial processes. Masoneilan *Point 4 Factor Trim* provides standardization, plus convenience in selection and procurement in handling these unusual applications.

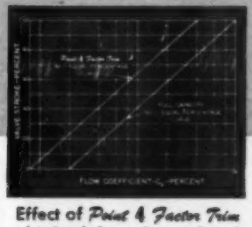
Complete details are available on request.



Effect of reducing *maximum* flow by altering plug contours only.



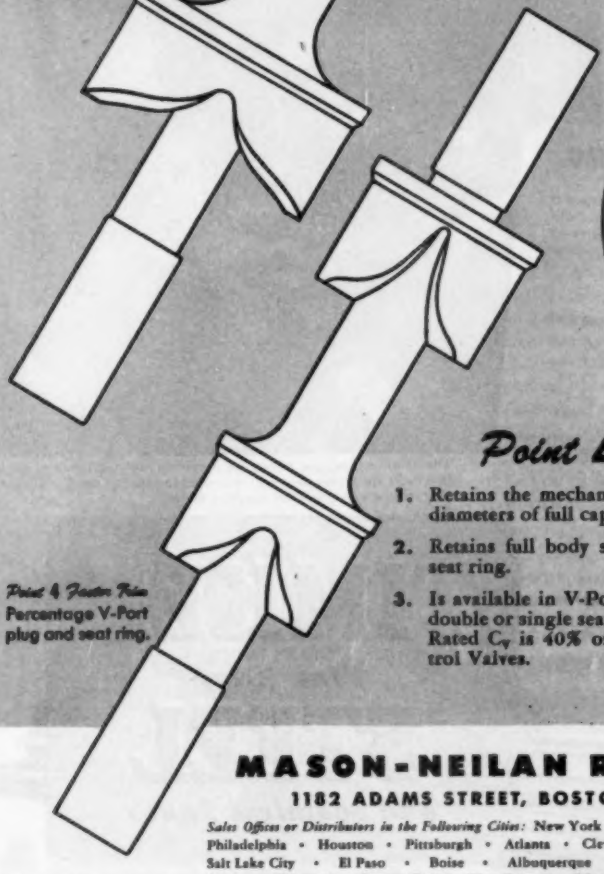
Note that same reduction of *maximum* flow can be obtained by reducing stroke by means of positioner adjustment or altered spring characteristic.

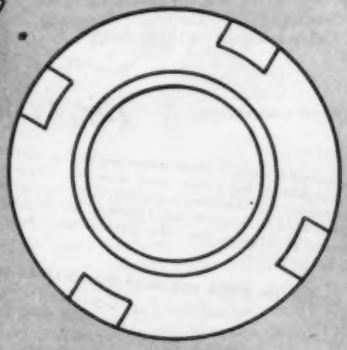


Effect of *Point 4 Factor Trim* obtained by using reduced plug and seat ring diameters.

Contribution to Simplified Valve Selection

Full capacity Percentage V-Port plug and seat ring.





Point 4 Factor Trim Percentage V-Port plug and seat ring.

Point 4 Factor Trim

1. Retains the mechanical strength, stroke, stem and guide diameters of full capacity trim.
2. Retains full body size with reduced diameter plug and seat ring.
3. Is available in V-Port and solid turned plug designs, for double or single seated valves — sizes 1¼″ to 8″ inclusive. Rated C_v is 40% of full capacity of 10,000 Series Control Valves.

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This month's report is on: **4-6% CR.-MO.**

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DM-2	2¼% Cr.-1% Mo.	Sicromo 7	25-12
Silmo	Sicromo 3	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	

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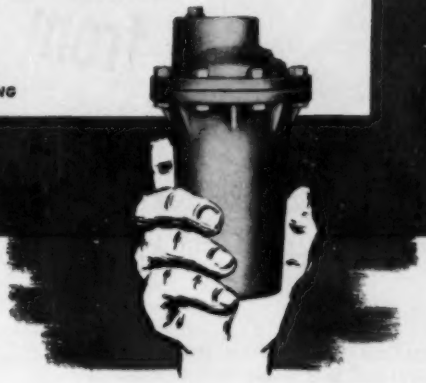

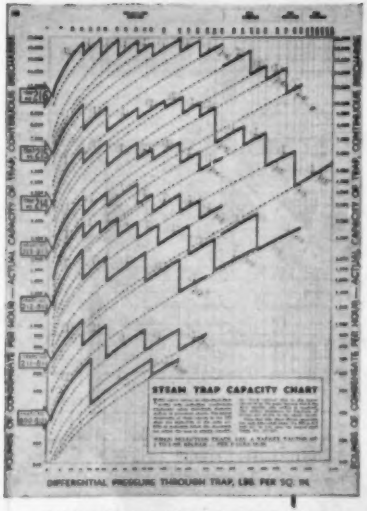

IT PAYS TO KNOW BEFORE YOU BUY!

THE ARMSTRONG STEAM TRAP CAPACITY CHART is based on hundreds of tests with hot condensate. You can depend on its accuracy.

SEE OUR CATALOG IN SWEETS OR CEC

THEORETICAL calculations fail entirely to give a true picture of trap capacity. Orifice tests fail to account for capacity losses caused by pipe friction. Tests with cold or warm water do not take into consideration the capacity-reducing effect of flash steam. Only tests with actual trap hookups handling hot condensate will tell you the true continuous discharge capacity of a steam trap—and those are the capacities Armstrong gives you.

If capacities are misleading you may buy a trap too small for the job. Or, if you compare different makes of traps on a price basis you must know if they are comparable on a capacity basis or the comparison means nothing.

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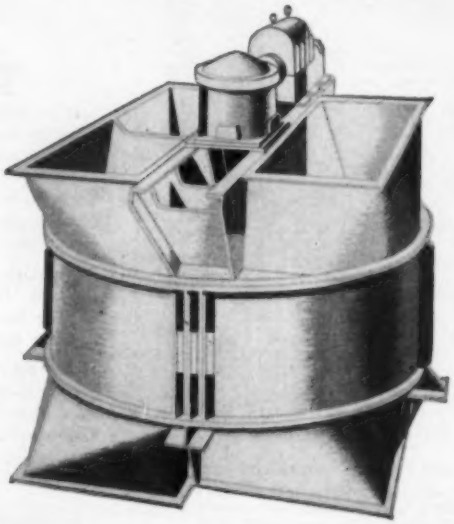
In addition, the *continuous regenerative counterflow principle* of the Ljungstrom permits reliable operation at low exit gas temperature. This assures the greatest possible heat recovery . . . reduces the amount of fuel required.

If you are planning a new installation, or modernizing your present one, our engineers will welcome the opportunity to show you how the Ljungstrom can enable you to get better results from low-grade, less costly fuels.



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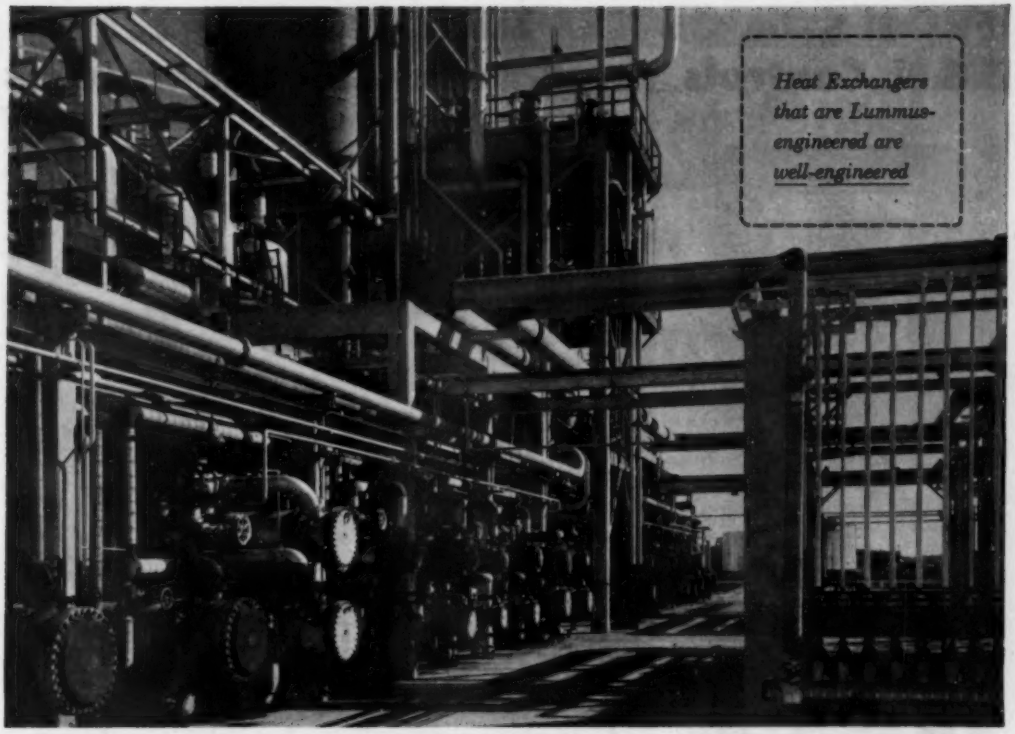

Picture of a bank with a favorable exchange rate

No marble, vaults, or tellers' windows here! This is a bank of Lummus Heat Exchangers. They are part of Cit-Con Oil Corporation's 12,500 B/D "Twin" Vacuum Distillation Units at the Lake Charles, La., refinery.

They're paying off, too! Reflecting the design ingenuity of Lummus engineers, these units are helping to achieve maximum heat economy . . . hence lower lube oil manufacturing costs.

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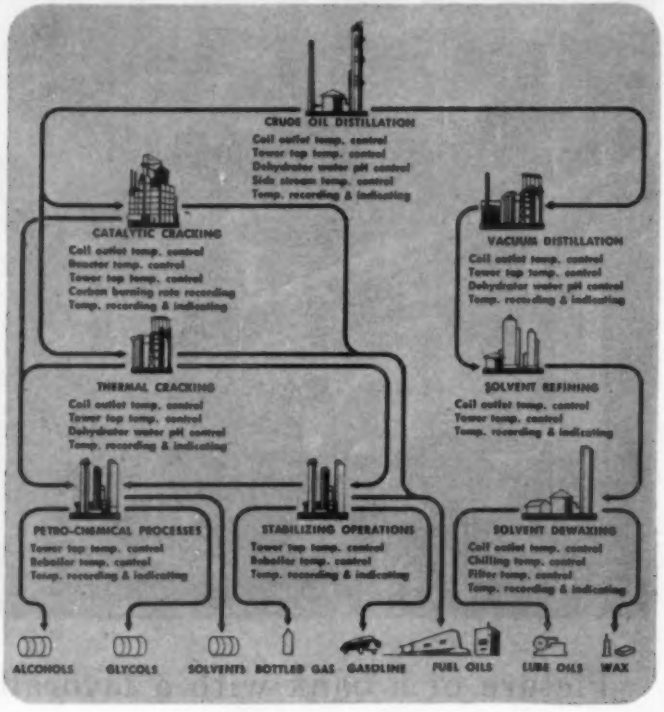

From coil outlet to tower top—from reactor temperature to dehydrator pH—L&N pneumatic controls are giving refinery men a new concept of the possibilities of modern automatic control.

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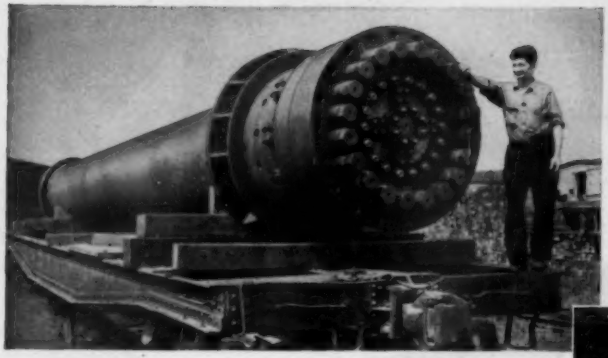

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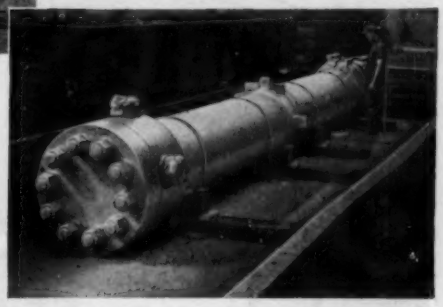

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No size or weight limitations as **MULTI-LAYER** vessels or heat exchangers can be made in any diameter for which satisfactory end closures are available.

The full calculated strength of the steel is more fully utilized in **MULTI-LAYER** vessels. Wrapping tension and weld shrinkage develop compression in the inner layers. This results in more equalized loading of all portions of the vessel wall under working pressure.

Safety is greatly improved by **MULTI-LAYER** construction. Only the inner cylinder need be pressure tight! Outer layers are provided with vent holes which protect the vessel against damage from over-pressure. In the remote event of run-away overload sufficient to cause failure, there is little danger of fragmentation of the vessel wall, due to the nature of **MULTI-LAYER** construction.

Consult A. O. Smith for assistance on your heat-exchanger or pressure-vessel problems. In any event, write for Bulletins V-52 and V-53 for more complete information on **MULTI-LAYER** Pressure Vessels and their construction . . . or use handy coupon.

77th ANNIVERSARY 1856 · 1951

A.O.Smith

VESSELS • HEAT EXCHANGERS

Boston 16 • Chicago 4 • Cleveland 15 • Dallas 2 • Denver 2
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A. O. Smith Corporation
Dept. PR-651, Milwaukee 1, Wis.

Without obligation, send me Bulletins V-52 and V-53 on your **MULTI-LAYER** Pressure Vessels and their construction.

Name_____
Firm_____
Street_____
City_____ State_____

A digester being radiographed with two-million-volt X-ray equipment
QUALITY
BY THE TON
... process
equipment
by
B&W

Today, fabricating capacity and mechanical design facilities alone cannot provide an adequate solution to the equipment problems imposed by modern processing temperatures, pressures, and stepped-up cycles of operation.

Design and construction of vessels and heat-transfer equipment necessarily involve such relatively new research data as creep characteristics and the metallurgy and methods of welding dissimilar metals and alloys. B&W is particularly well equipped . . . both by research and experience . . . for the proper selection of materials, their fabrication, and integrated assembly to meet the special requirements of modern chemical, petroleum, and food processing.

No matter how "big" you buy, you can still think in terms of *quality* — fine engineering, conscientious craftsmanship, experience, and the ultimate in critical inspection — when B&W contracts for the job. The Babcock & Wilcox Company, 85 Liberty Street, New York 6, N. Y.

Quality material and workmanship are required for high alloys that operate at severely high temperatures

BABCOCK & WILCOX

S-4067

A "K" Monel doctor blade in use on a soap flaker dryer roll. After 7 months of highly satisfactory service, this blade was transferred to rolls used for polishing soap, setting a record for doctor blade longevity in the plant.

The Doctor Was a Headache

...until they tried "K" MONEL

In a soap flake plant, flaker roll doctor blades were a source of considerable trouble and expense.

The blades were operated against a cast iron cooling roll, 5 ft. in diameter with a 90 in. face, which handled 72,000 pounds of soap every 24 hours.

Although made of the finest Swedish steel, doctor blades had to be honed every hour, and reground every 24 hours. It took only ten minutes to change a blade, but in that short time 500 pounds of soap production were lost.

After putting up with the problem for some time, plant engineers decided to try doctor blades made of "K" Monel®.

Results? Judge for yourself! Here is what the plant engineers reported:

1. "K" Monel doctor blades (0.031 in. thick by 4 in. wide) required honing only once in 24 hours.

2. "K" Monel blades gave 27 continuous days of service before needing regrinding.

3. It took more than 7 months to reduce the width of a "K" Monel blade from 4 in. to 2¾ in.

Switching to "K" Monel doctor blades gave them 24 times more service between honings, 9 times more service between regrinds, and saved uncalculated production poundage formerly lost through frequent blade changes.

Not always, of course, can such spectacular gains be made merely by changing the material of a doctor blade. But here's something to remember—

There are special INCO Nickel Alloys for almost every doctor blade application . . . alloys that have a proved record of reducing maintenance costs and speeding production.

Find out more about these important alloys by asking for your copy of: "How to Get More Production from Doctor Blades." Right now, of course, INCO Nickel Alloys are being diverted more and more to defense production, so you may have to wait for the metal you want.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE
NICKEL INCO **ALLOYS**

MONEL® • "K"® MONEL • "KR"® MONEL • "R"® MONEL • "S"® MONEL
NICKEL • LOW CARBON NICKEL • DURANICKEL®
INCONEL® • INCONEL "X"®

ESSO STANDARD OIL COMPANY

Uses

A. P. GREEN SK-7 KS-4

for Regenerator Lining

The regenerator of this huge Esso Standard Oil Company cat-cracking unit is lined with A. P. Green SK-7 and KS-4. It has been giving excellent service.

Application of SK-7 completed. Steel mesh attached to studs preparatory to shooting KAST-SET KS-4.

Interior of Catalytic Regenerator showing the completed lining with the KAST-SET KS-4 applied over the CASTABLE No. 20 SK-7.

CHECK THESE ADVANTAGES OF SK-7 and KS-4

1. Cuts installation time and labor costs
2. Construction costs held to minimum
3. Rebound loss reduced
4. Adaptable to a variety of installations
5. Results in linings with balanced characteristics of poured castables

Esso Standard Oil Company, Linden, New Jersey, is one of the leaders in the petroleum industry who use A. P. Green SK-7 and KS-4 for lining regenerators in cat-cracking units. The contour of cat-cracker regenerators lends itself to the use of these specially designed and engineered gun-applicable refractory castables.

CASTABLE No. 20 SK-7 is a lightweight insulating castable recommended for a service temperature of 1800° F. KAST-SET KS-4 is a castable refractory with a top service temperature of 2750° F. Both were designed specifically for gun application in the Petro-Chemical industry.

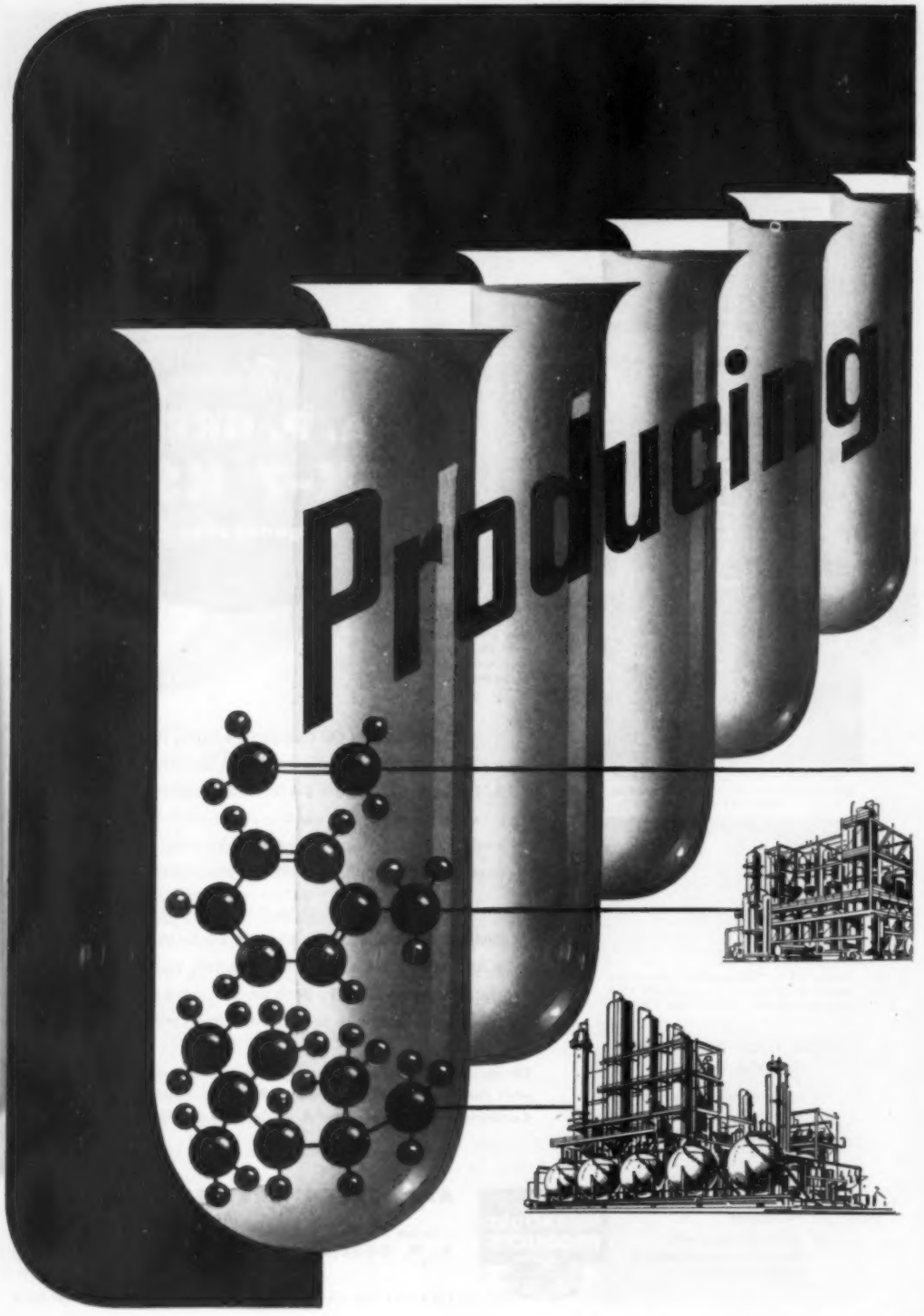
For detailed information concerning these castable refractories, write the Engineering Department of the A. P. Green Fire Brick Company — or call your local A. P. Green Distributor.

A. P. Green REFRACTORY PRODUCTS

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

In Canada
A. P. GREEN FIRE BRICK COMPANY, LTD.
Toronto 15, Ontario

DISTRIBUTORS IN THE PRINCIPAL CITIES OF THE WORLD

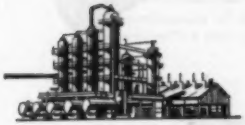

Producing

UNKNOWN

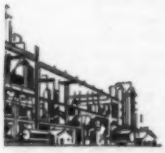
Badger can be of great assistance to you in speeding development of new products or processes from your laboratory to full commercial production.

Badger's reservoir of engineering knowledge and experience can save you months in process investigation.

Badger planning includes consideration of long range factors such as need for expansion and the effect of possible technical and economic developments.



When Badger handles all details of engineering, procurement and construction you eliminate the necessity of expanding your own organization. Badger's *single responsibility* often results in considerable savings in time and money.



When your organization must rapidly complete process facilities involving new concepts get in touch with Badger.

E. B. BADGER & SONS CO. • Est. 1841

A SUBSIDIARY OF STONE & WEBSTER, INC.

BOSTON 14 • NEW YORK

LONDON E. B. Badger & Sons (Great Britain) Ltd.

Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries

PAINTED
to resist rust...

PRECISION-MADE
to resist blowouts...

...this Heat Exchanger Gasket will stay on the job longer

The durable coating of red paint on every Goetze iron or steel-jacketed Style 923 Heat Exchanger Gasket is a sure "stop light" against rust. And rust, as every metal gasket user knows, is a primary cause of deterioration—both in the storehouse and on the job awaiting installation.

Equally important in the fabrication of Style 923 is the precision craftsmanship which eliminates cracks and wrinkles in the metal jacket—defects which can rapidly lead to leaks and blowouts.

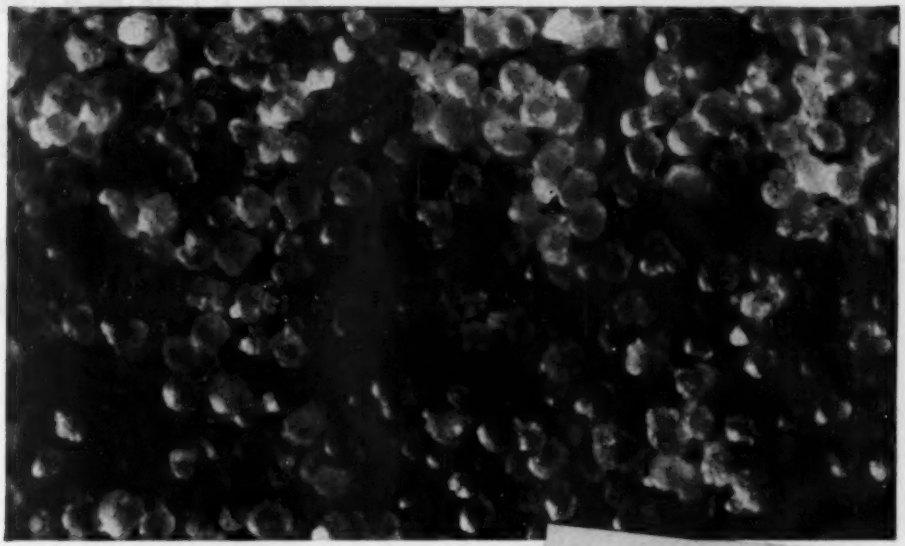
"Custom tailoring" accounts for the meticulous care which is taken in the forming of every one of these gaskets... care which results in a long, efficient service life. You can always depend on a Goetze Style 923 to fit and seal perfectly... to stay on the job without leaks or blowouts. And that, of course, pays off in less down time and fewer gasket replacements.

Find out how little it costs to have Goetze Heat Exchanger Gaskets "tailored" to the size and shape *you* need. For prompt estimates and recommendations, write Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville *Goetze* GASKETS

THERE'S A JOHNS-MANVILLE PACKING AND GASKET FOR EVERY SERVICE.

Nalcat MS CRACKING CATALYST
with NARROW PARTICLE SIZE DISTRIBUTION



Photomicrograph of Nalcat MS, highly magnified. Note narrow particle size range and spheroidal characteristics.

DISCUSSIONS with refiners throughout the country brought numerous suggestions as to the desired particle size distribution for fluid cracking catalyst. The consensus, however, fell into two main categories: Refiners with secondary recovery equipment appeared to seek a catalyst with a particle size range essentially of 20-80 microns, while those without secondary recovery equipment seemed to prefer catalyst with a range of approximately 40-100 microns.

Our commercial grades of Nalcat Microspheroidal Catalyst were therefore designed accordingly. Data at the right shows that Nalcat Grade MS-1 well meets the needs of the first group above, and Nalcat Grade MS-2 fulfills the requirements of the second group.

If your particular situation calls for a different particle size distribution, however, we will be glad to work with you in developing a tailor-made catalyst for your needs. In this respect, Nalcat spray drying facilities of new design lend themselves ideally to such a project.

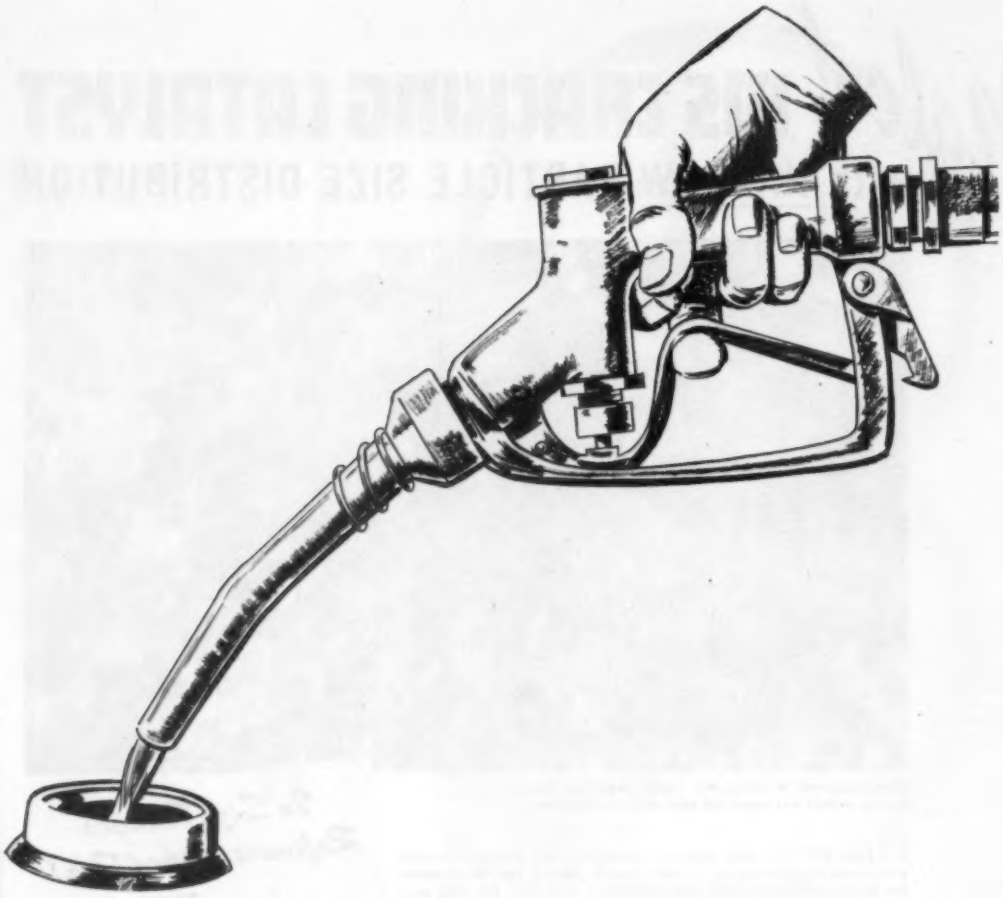
Full details on both ground and microspheroidal Nalcat Catalysts will be furnished upon request.

In Size Ranges Refiners Asked For!

	NALCAT Grade MS-1	NALCAT Grade MS-2
BY SCREENING		
% through 100 mesh (149 microns)	100	100
% through 200 mesh (74 microns)	92	80
BY SEDIMENTATION		
% minus 40 microns	30	10
% minus 20 microns	3	2
% minus 10 microns	0	0

Ground and MS Catalysts
for Maximum Efficiency... Highest Purity

CATALYST DIVISION—NATIONAL ALUMINATE CORPORATION
4001 West 71st Street • Chicago 29, Illinois



SANTOLENE C ACCEPTED

as corrosion inhibitor in combat-grade gasoline

Monsanto Santolene C has been accepted as a corrosion inhibitor—at the option of the supplier—for combat-grade gasoline by the Ordnance Department under specification MIL-G-3056. Write today for details on how you can use Santolene C to add rust-preventive properties to your gasoline, Diesel fuel, kerosene and fuel oil . . . how you can employ Santolene C to control corrosion in tanks, lines and equipment handling any light petroleum product.

The effectiveness of Santolene C has been proved in the laboratory and in the field. These findings have been confirmed by a major oil company which has marketed Santolene C in all types of light petroleum products for more than a year.

Santolene C is product-soluble. It burns completely with the fuel, leaving no residues whatever. Diesel and gasoline engine tests have demonstrated that Santolene C has no effect on engine cleanliness, injector fouling or any other factor of engine performance.

For technical information on the use of Santolene C to solve corrosion problems, write, wire or telephone MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1775-E South Second Street, St. Louis 4, Mo.

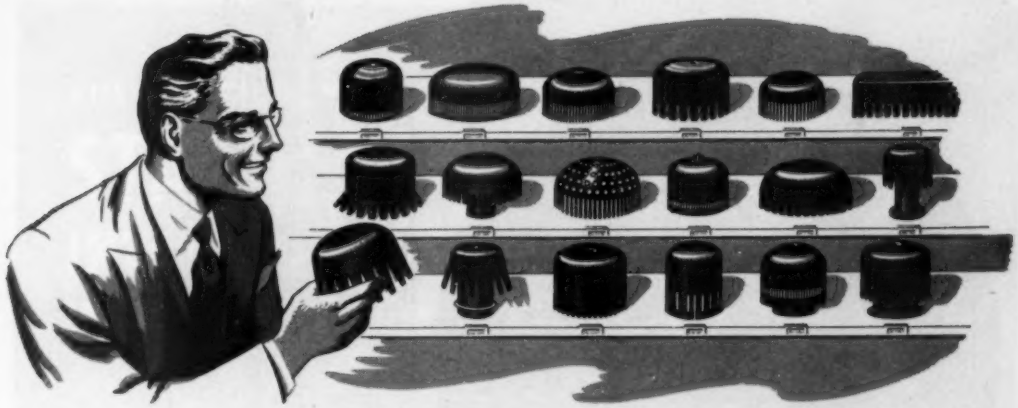
URGENT—If you have empty carboys or returnable drums, please return them to your supplier promptly. They're urgently needed. Containers are scarce!

Santolene: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS AND PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

If You Don't See What You Want—*Ask for It*



PSC Furnishes Over 200 Standard Styles of Bubble Caps and Risers. But We Will Gladly Help You Design Special Units

Any time you are in need of purchasing data on bubble caps may we suggest that you refer to our Bulletin 21 or The Refinery Catalog. In both sources you will find the largest compilation of bubble cap and riser data in print, covering over 200 standard styles furnished by The Pressed Steel Co. Should you not see the style or cap you need we invite you to ask us about your requirements.

WE SAVE YOU THE COST OF DIES

As fabricators of the widest line of bubble caps, we offer you a broad experience in the production of special caps to meet specific refinery conditions.

Should you find among our line of standard caps a style to meet your needs we can save you the cost of dies as well as make prompt delivery. Send blue prints or write as to your needs.

NEW LE JONS ASSEMBLY SAVES 7 WAYS

PSC bubble caps are furnished for all methods of tray assembly. Included is the new Le Jons method, which features unprecedented simplicity.

Send for **BUBBLE CAP BULLETIN 21**

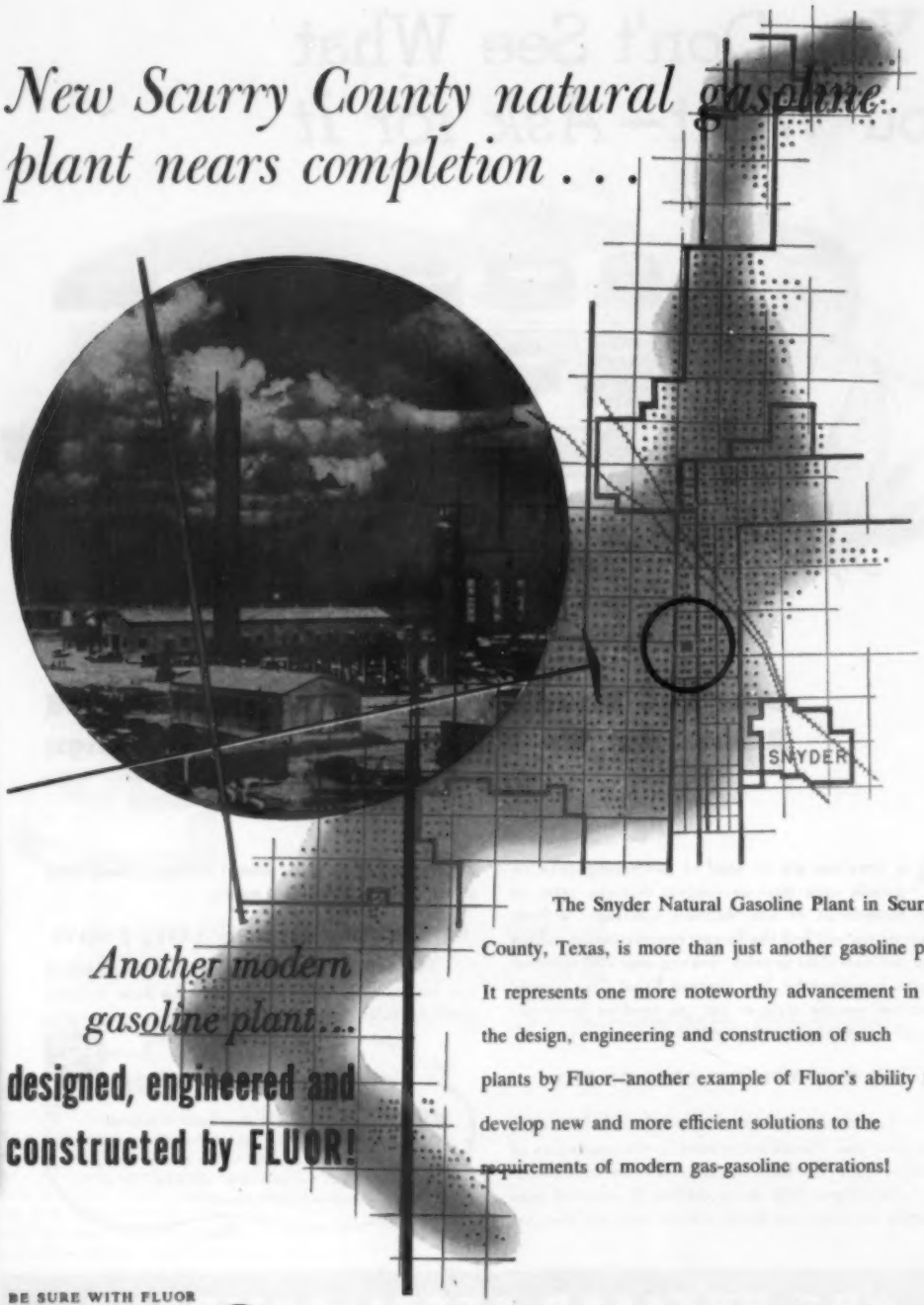
Largest compilation of engineering data on bubble caps and risers in print. Also contains drawings for use in determining methods of tray assembly. **BULLETIN 31** *describes Le Jons assembly.*

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

New Scurry County natural gasoline plant nears completion . . .



Another modern gasoline plant . . .

designed, engineered and constructed by FLUOR!

The Snyder Natural Gasoline Plant in Scurry County, Texas, is more than just another gasoline plant. It represents one more noteworthy advancement in the design, engineering and construction of such plants by Fluor—another example of Fluor's ability to develop new and more efficient solutions to the requirements of modern gas-gasoline operations!

BE SURE WITH FLUOR

FLUOR

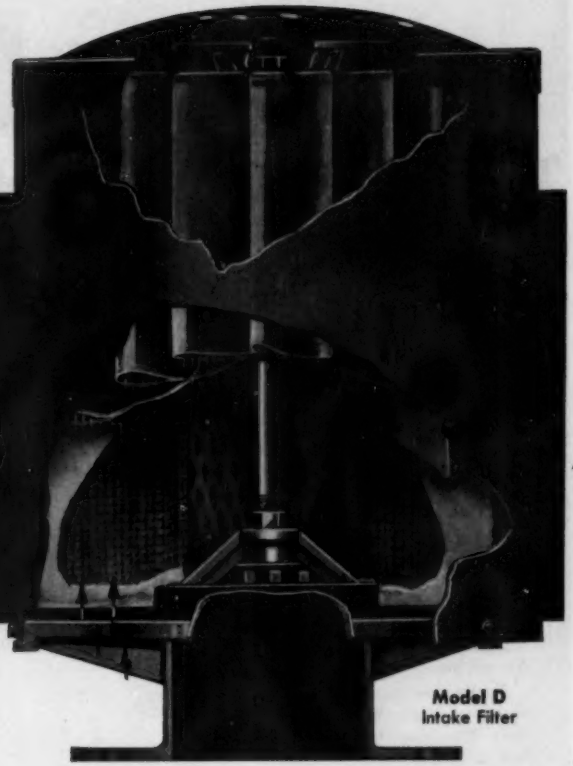
DESIGNERS AND CONSTRUCTORS of Refining, Natural Gas and Chemical Processing Plants.
MANUFACTURERS of Pulsation Dampeners, Cooling Towers, Fin-Fan Units, Gas Cleaners and Mufflers.

THE FLUOR CORPORATION, LTD., 2500 S. Atlantic Blvd., Los Angeles 22, California
New York, Chicago, Pittsburgh, Boston, Tulsa, Houston, San Francisco, Birmingham and Calgary.

REPRESENTED IN THE STERLING AREAS BY: Head Wrightson Processes Ltd., Teesdale House, Baltic Street, London, E.C.1., England

NOTE:
To Men Responsible for Engine and Compressor Operation

THE EFFICIENCY OF STAYNEW INTAKE FILTERS INCREASES WITH USE



Model D
Intake Filter

This fact can mean the difference between *full* and *seriously reduced* output . . . between *frequent repairs* due to intake of abrasive, clogging dust and *no repairs*.

All Staynew Intake Filters are Dry-type — no moving parts, no reservoirs, no liquids. Air velocity is not critical, temperature extremes have no effect. As dust accumulates on the medium, filtering efficiency increases — *yet tests prove that resistance may reach less than 2.75" water after thousands of hours of operation.* Radial Fin design of insert and all-wool felt medium provide unsurpassed protection . . . virtually 100%. More than 600,000 Staynew Intake Filters have been placed in service. *A fine engine or compressor deserves a fine filter.* Specify Staynews for more HP or CFM at lowest possible cost.

Bulletin SIF On Request

Model KE
Economy Filter

Model C
Small Capacity Filter

Model DS
Silencer-Filter

A 12"x12" Staynew Radial Fin Insert Has 2059.2 Sq. In. Active Filtering Area—the same proportion as this panel bears to Insert below

This filtering area in Insert this size.....

Model IDR
Ground Level Servicing, High Level Intake Filter

DOLLINGER PROTECTOMOTOR STAYNEW FILTERS

DOLLINGER CORPORATION 47 CENTRE PK., ROCHESTER 3, N.Y.

FILTERS FOR: ENGINES • COMPRESSORS • PIPE LINES (AIR, GAS, LIQUID) • VENTILATION

Pick The Make That Lets YOU Pick

exactly the design you need

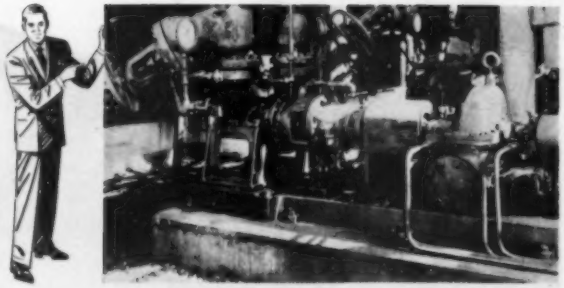
Worthington has a centrifugal pump for practically any conceivable refinery requirement—in the most complete range of sizes.

The pictures here show only a few of the many purposes served by Worthington Centrifugals. Whether your problem is high temperatures . . . volatile liquids . . . abrasives . . . acids . . . or any of the host of others that harass refineries — the Worthington line includes the one best pump for the job.

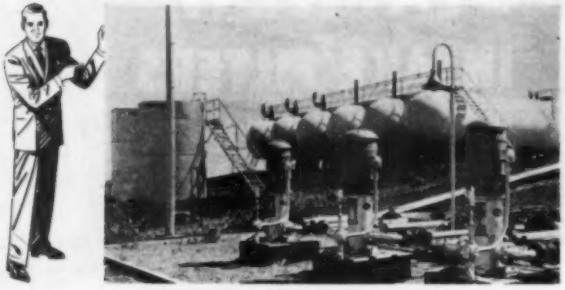
Further assurance you enjoy when you standardize on Worthington: you know that Worthington, making the broadest line of pumps, will recommend the best type for each job—you know you'll benefit from *engineering* that's the finest in the business—and you know you can depend on *service* that does its best to keep you in peak production.

Write us for bulletins on the types in which you're interested and see why *there's more worth in Worthington*. Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.

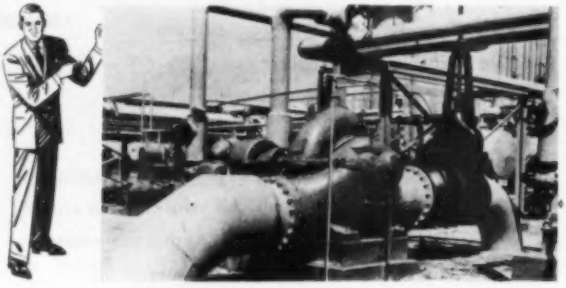
SEE OUR CATALOG IN SWEET'S



WORTHINGTON HR CENTRIFUGAL, shown at Sun Oil Co., Marcus Hook, Pa., is typical of pumps used in distillation, cracking and treating petroleum products.



WORTHINGTON QER VERTICAL centrifugal process pump, shown at Magnolia Petroleum Company, Chitwood, Oklahoma, is used to transfer propane, butane and LPG.



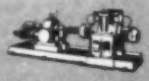
WORTHINGTON LA CENTRIFUGAL, turbine-driven, shown at Carthage Corporation plant, Carthage, Texas, is typical of cooling tower and general service pumps.

THE WORLD'S BROADEST LINE ASSURES YOU THE RIGHT PUMP FOR EVERY JOB

WORTHINGTON

C1.4

Types HR and HB Capacities to 1800 gpm. Heads to 900 ft. Temperatures from far below zero to 600 F. Pressures from high vacuum to 750 lb. gauge.



Type HD Hydraulically-balanced, double-suction impeller handles boiling liquids with low submergence. 600 to 3200 gpm. Heads to 700 ft. temperatures to 850 F, pressures to 350 lb.

Type CNE For loading or transfer services. Capacities to 1500 gpm. Heads to 500 ft.

Type HBA Available in 12 sizes. Capacities to 700 gpm. Heads to 450 ft. Maximum temperatures 500 F.

Industry looks to Powell

for the latest improvements in

VALVES

That's because Powell never believes in "letting well enough alone," but is continually producing more advanced designs to meet the requirements of modern methods and processes.

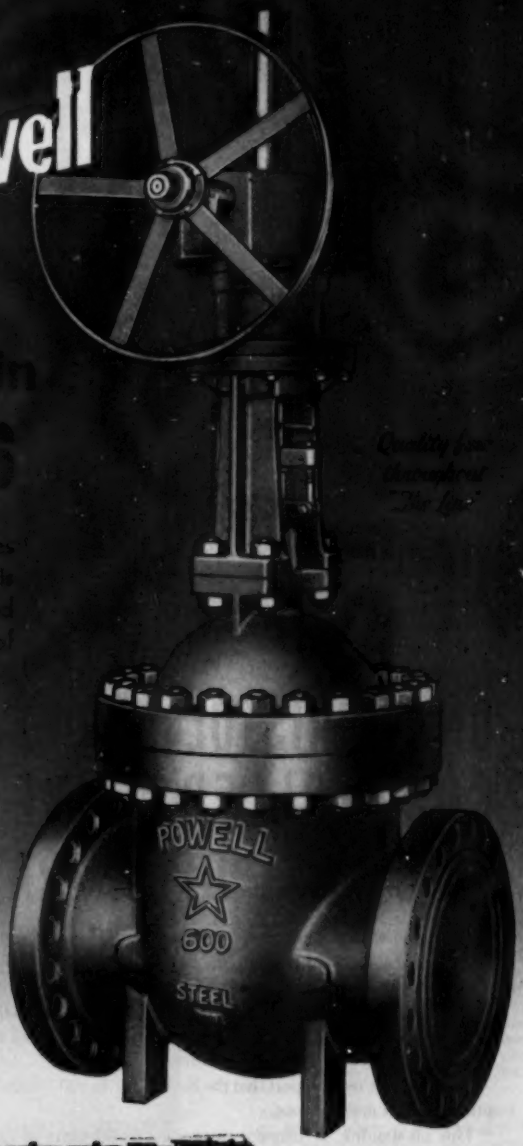
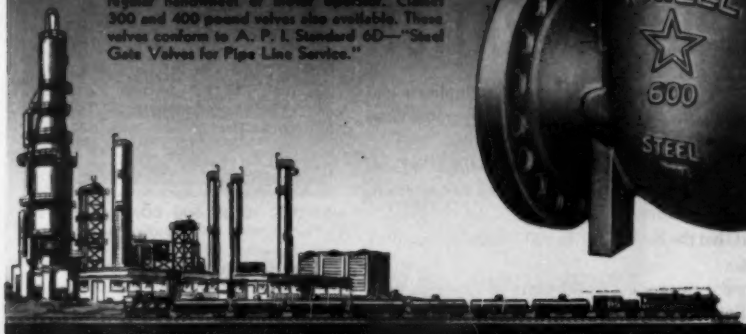
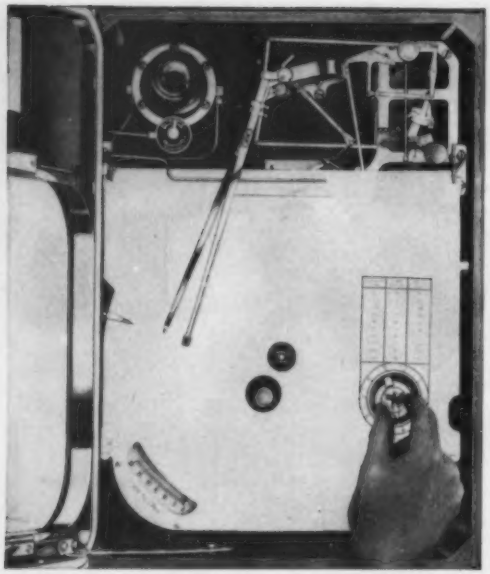


Fig. 6079—Class 600-pound Cast Steel Double Disc Parallel Seat Gate Valve for Pipe Line Service. Gear operated. Can be supplied with regular handwheel or motor operator. Classes 300 and 400 pound valves also available. These valves conform to A. P. I. Standard 6D—"Steel Gate Valves for Pipe Line Service."

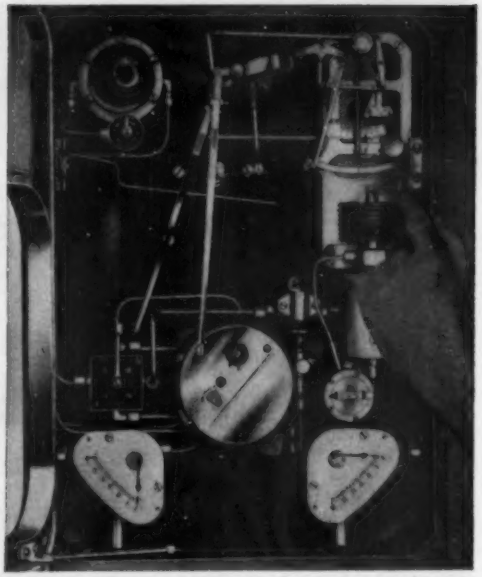


POWELL

The WM. POWELL CO., 2525 Spring Grove Ave., P. O. Box 106, Station B, Cincinnati 22, Ohio



EASIEST TO PUT INTO OPERATION—Calibrated control actions save hours of shutdown. Reset, derivative and proportional values can be exactly reproduced at any time on the same or any other Series 500 controller . . . merely by duplicating the setting. Thus: controller adjustments can be standardized for any process throughout a plant or national organization.



EASIEST TO SERVICE—Inherently simple design, using the fewest possible parts, plus extremely close-tolerance manufacturing . . . make the instrument thoroughly interchangeable, trouble-free and a cinch to service. For example: only one simple adjustment puts the system in exact calibration even after complete disassembly and reassembly.

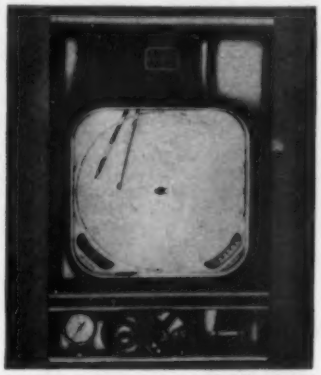
ONLY BRISTOL SERIES 500 CONTROLLERS GIVE YOU THIS EASE OF OPERATION

When you wish to reproduce a previous control action or duplicate one taking place at some other point, the Bristol Series 500 Air-Operated Controller permits you to do it merely by setting a dial.

Or, should the instrument require servicing, only one simple adjustment is needed to calibrate the control system and put it back in operation. Almost anyone can service this instrument.

Furthermore, users report that the Bristol Series 500 Controller requires practically no maintenance.

This outstanding instrument—a product of 60 years of experience—is completely described in Bulletin A120. THE BRISTOL COMPANY, 111 Bristol Road, Waterbury 20, Conn.



BRISTOL SERIES 500 CONTROLLERS are offered in five types—on-off, proportional, reset, derivative, reset plus derivative—to control temperature, flow, pressure, liquid level, humidity, pH. Conversion from one type to another can be made by the user. Model shown has external-manual station with mechanical interlock for test and service.

BRISTOL

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Lasts longer in corrosive service

This acid-shield ALOYCO gate valve is made in a wide range of analyses to specification, and is regularly stocked in popular alloys.

Like all ALOYCO valves, its dependable performance results from:

A. Metallurgical research devoted *exclusively* to corrosive applications;

B. foundry and machine shop facilities set up for *only* high alloys;

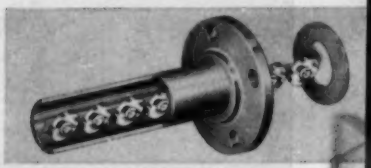
C. casting and machining practices dictated by the difficult characteristics of the alloys required for corrosive services.

Success Stories from ALOYCO's Corrosion Clinic

THE CORROSIVE: acid sludge.

THE PLACE: Esso Standard Oil Refinery, Baton Rouge, La.

THE VALVE: ALOYCO Figure 1103 Hastelloy D gate valves. Field tests made by The Aloyco Corrosion Clinic clearly indicated that Hastelloy D would do the job. Problems of fabricating this hitherto unmachinable alloy were solved by Alloy Steel Company production men. Now Hastelloy valves are used in many applications such as Esso Standard's.



Orifice-type test rods exposed in customers' pipeline are studied to determine proper specification of valve material.

THE BACKGROUND: The *Aloyco Corrosion Clinic* is a service to chemical process engineers who encounter problems of corrosive damage to valves.

Alloy Steel Products Company maintains the *largest* laboratory devoted *exclusively* to the "diagnosis" and "treatment" of problems relating to valves in corrosive service. From the results of laboratory and field testing, it develops the specifications for customers' applications.

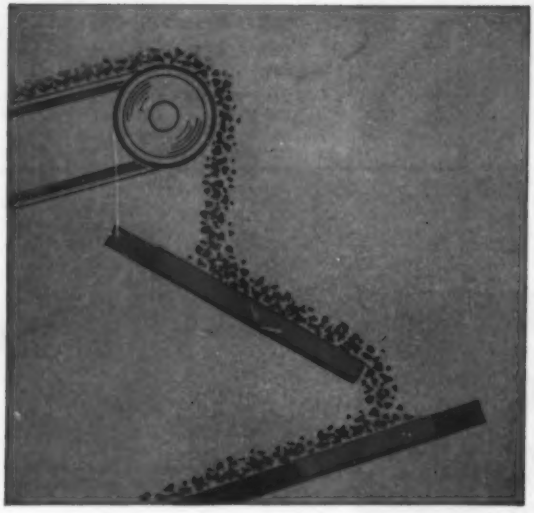
Its success in lengthening valve life on corrosive services explains why *more* ALOYCO corrosion-resistant valves are used than any other brand.

If *your* plant deals with severe corrosives or must guard against product contamination or discoloration, put your problem before The *Aloyco Corrosion Clinic.*

ALLOY STEEL PRODUCTS CO., INC.
1303 West Elizabeth Avenue, Linden, N. J.

Longer Lasting
ALOYCO VALVES
1st in Corrosive Service

abrasion?



erosion?

Here are even tougher

The weak link in keeping certain equipment on the production line often lies in rapid abrasion and erosion of vulnerable areas. For example:

In Cyclone Dust Collectors where there's a ceaseless blast of highly abrasive particles.

In Coke Chutes and Hoppers which must withstand constant cascades of fiery coke or cold coke.

In Hot Blast Mains through which dust-laden gases travel at high velocities.

In Billet Heating Furnaces through which hundreds of massive metal slabs are pushed.

Under conditions like these, metals, paving bricks and other normally durable materials are simply worn away — and in very short order. It takes exceptionally tough linings or bearing surfaces — as provided by our MONOFRAX K fused cast blocks or our CARBOFRAX silicon carbide bricks and shapes — to stand the gaff.

Both these Super Refractory materials by CARBORUNDUM *are within one index point of diamond hardness!* It is this hardness that gives these Super Refractories their exceptional resistance to abrasion—from room temperature to high heats.

Granted, abrasion is seldom an isolated condition. It's usually abrasion *plus* . . . heat, or acid attack, or some other condition. But, as you can see (top, opposite page), these Super Refractories have many other properties, equally as desirable as abrasion resistance and equally important in certain applications.

Information is now available on all the various groups of Super Refractories by CARBORUNDUM. Just send the coupon and you'll receive our new booklet. No obligation, of course.

THE CARBORUNDUM COMPANY

Refractories Division • **Perth Amboy, New Jersey**

"Carborundum," "Carbofrax," "Monofrax" and "Alfrax" are registered trademarks which indicate manufacture by The Carborundum Company.

SUPER REFRACTORIES ARE ALSO USED

WHERE HEAT CONDUCTIVITY IS NEEDED. At elevated temperatures CARBOFRAX refractories conduct heat as rapidly as chrome-nickel steels! This characteristic is invaluable in checkers, muffles, hearths, etc.

WHERE CHEMICAL ACTION IS PRESENT. In general, all Super Refractories are either neutral or acid in nature — are widely used where chemical inertness is important.

WHERE STRENGTH IS IMPORTANT. No commercial tonnage refractories have greater strength than Super Refractories. All can withstand over 300 psi at 2750° F without crushing.

WHERE HIGH HEAT IS INVOLVED. They can be safely used at temperatures over 3000° F. They are very durable — are highly resistant to spalling and cracking. Some varieties are almost indispensable where flame impingement or violent temperature changes are present.

WHERE INSULATION IS NEEDED. One of these products, ALFRAX BI aluminum oxide material, consists structurally of many hollow spheres. It's one of the best insulating materials at very high temperatures.

WHERE SPECIAL SHAPES ARE INDICATED. Practically all Super Refractories are available either as bricks or special shapes molded to close tolerances — including fitted joints, tubes, etc.

Do any of these suggest possible applications?

materials of construction than grinding wheels

The important thing about Super Refractories by CARBORUNDUM is NOT just that they are "better" than standard fireclay refractories. The important thing is that they are actually *a class apart* — with many entirely different properties and applications. (For example, some of their properties — such as abrasion resistance — are important *regardless of whether high temperatures are involved.)*

Nor is their principal value simply that they cure trouble-spots where other materials (e.g., refractories, metals, etc.) fail to stand up. Their value usually lies in increasing capacity and reducing overall operating costs. (For example, regenerator checkers made of CARBOFRAX brick absorb and release over 3 times as much heat as checkers made of ordinary refractories when cycles are short.)

WHY NOT CHECK UP? We have a new booklet which outlines the unusual characterictics of these special purpose materials. The coupon will bring you the story — or one of our engineers would be happy to talk over your specific problems. We believe it could be mutually profitable.

This advertisement — one of a series — is presented in the belief that in the unusual properties of the various Super Refractories by CARBORUNDUM lies the key to many new or improved processes. We would like to talk over specific jobs with anyone who sees such possibilities.

Dept. T-61
Refractories Div., The Carborundum Co.
Perth Amboy, New Jersey

Please send your free booklet on properties of Super Refractories

Name_____

Position_____

Company_____

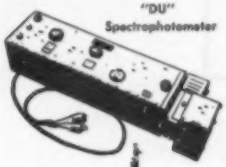
Street_____

City_____ Zone____ State_____

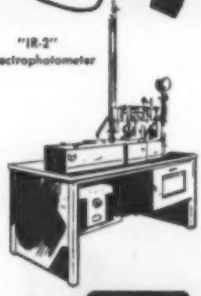
Mark of a *modern* refinery...

In both industry and science the name "Beckman" has become synonymous with leadership in a vital field of instrumentation—that of adapting complex scientific advancements to the quick, simple, accurate solution of modern production, analytical and control problems. If you are not using these Beckman Instruments in *your* operations, we suggest you investigate today the vital savings they can make for you...

"DU"
Spectrophotometer



"IR-2"
Spectrophotometer



Model "R"
pH Indicator

OTHER BECKMAN INSTRUMENTS include the Photopen Recorder, the Ultrohmeter, numerous types of Radiation Meters, and other advanced equipment for specialized applications. For modern instrumentation needs bring your problem to Beckman.

BECKMAN "DU" QUARTZ SPECTROPHOTOMETER:

Widely used by leading refineries to simplify the measurement and control of aromatics, butadiene and other refinery products that are readily analyzed by visible and ultraviolet light. With this instrument, complex analyses requiring many hours by other methods can be made—accurately—in a few minutes. Butadiene analyses can be made to an accuracy within 1/10 of 1% of total original sample.

Makes toluene determinations in minutes instead of hours—accurate to within 1% of toluene present over concentration range 0.01 to 100%. Also simplifies many other refinery applications with similar speed and accuracy.

Covers wide spectral range—near infrared, visible and ultraviolet—and entire instrument is designed for maximum accuracy, operating simplicity and compactness. Unusually rugged construction minimizes maintenance and insures sustained accuracy. Incorporates many unique design features. *Write for full details.*

BECKMAN "IR-2" INFRARED SPECTROPHOTOMETER:

Originally developed to simplify control problems in refinery operations, Beckman Infrared equipment and methods have been widely adopted by other industries as well.

The "IR-2" Spectrophotometer is the most advanced infrared equipment available and embodies far-reaching developments that greatly increase the versatility, accuracy, speed and convenience of modern infrared methods.

Analyzes hydrocarbons and other organic gases, liquids and solids by measuring absorption of infrared radiation at selected wave lengths, permitting rapid identification of each component—and its concentration—in complex mixtures. It is many times faster than other methods . . . is accurate to within ½ of 1% of *total* sample present . . . is simple to use and readily analyzes even the most complex mixtures encountered in modern refinery operations.

This instrument is widely used in leading refineries throughout the world, and no refinery, large or small, can be completely modern in its operating efficiency without Beckman "IR-2" equipment. *Write for full details on the many outstanding design and performance features incorporated into this equipment.*

BECKMAN GLASS ELECTRODE pH EQUIPMENT:

Extensively used throughout the refining industry to control pH in various processing operations, and to reduce costly corrosion of plant equipment by neutralizing acid crudes and similar corrosive elements.

Beckman—pioneer of modern glass electrode pH equipment—offers the widest range of pH instruments and the industry's most complete range of glass electrodes for use with its instruments.

There is a Beckman pH instrument for every application—laboratory, plant and field, as well as *completely automatic* equipment for large-scale pH indication, recording and control. Illustrated at left is the Beckman Model R Indicator for automatic pH installations, one in a complete range of pH instruments. *Write for descriptive details on Beckman pH equipment.*

Beckman Instruments, National Technical Laboratories, South Pasadena 25, Calif.

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BECKMAN **INSTRUMENTS CONTROL MODERN INDUSTRIES**
pH Meters and Electrodes — Spectrophotometers — Radiation Meters — Special Analytical Instruments

Are You Expanding in the "CIRCLE of SAFETY"?

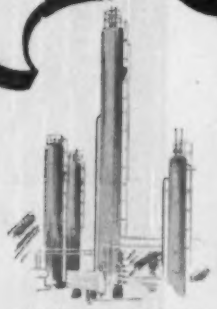
Contract Your Special Fabrication Nearby... Save Time and Money!

●Today, industry is tapping the resource-rich, protected midlands in its program of decentralization. Older plants are being enlarged or converted; scores of new plants are being rushed.

One problem has a ready solution. Use the vast, on-the-spot facilities of BS&B to fabricate special pressure vessels and large weldments! For over 58 years, BS&B has supplied precision, heavy-duty equipment to the oil and chemical industries. BS&B products have built a world-wide reputation for quality and efficiency.

BS&B's plants are fully equipped for rapid production of large, unusual assignments to the most exacting specifications. Heavy plate, alloys, odd shapes . . . they are all in a day's work to the skilled BS&B workmen and engineers!

Conveniently located close to the big, new industrial expansion areas. Fast transportation available at low rates. BS&B is your best bet for special fabrication! Write today for full particulars. All inquiries regarded as confidential.



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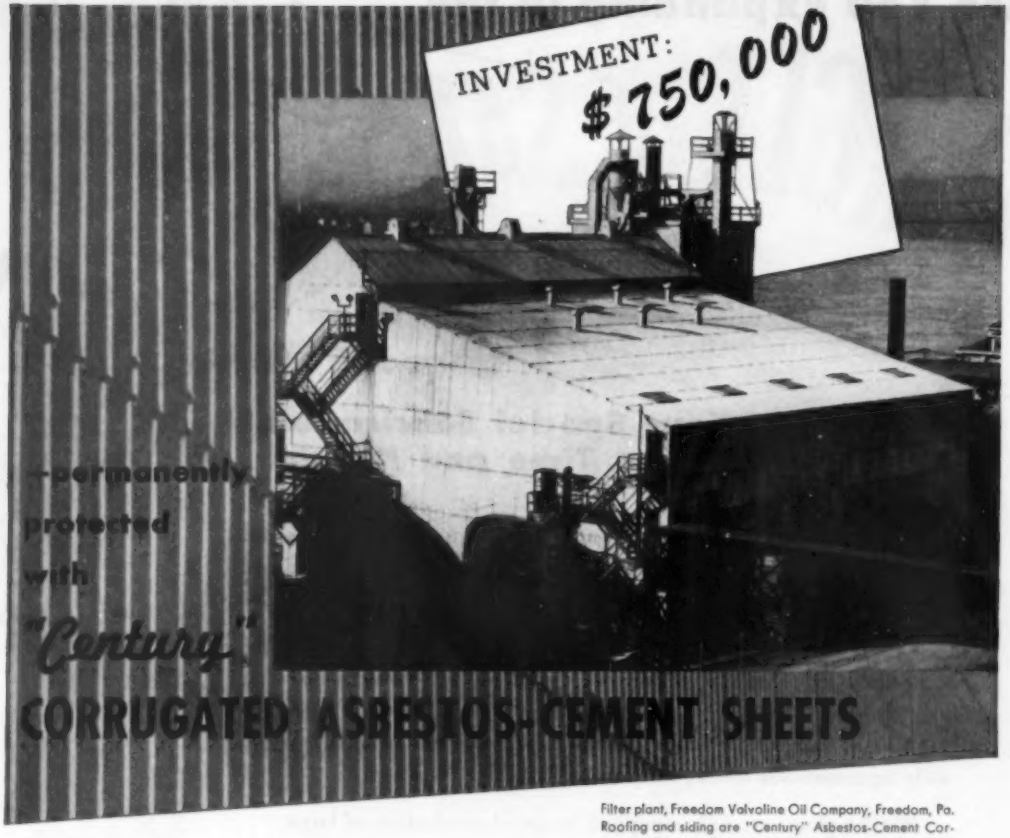

Filter plant, Freedom Valvoline Oil Company, Freedom, Pa. Roofing and siding are "Century" Asbestos-Cement Corrugated. Erection Contractors: Elwin G. Smith & Company.

THIS modern filter plant of the Freedom Valvoline Oil Company, Freedom, Pa. is typical of the many progressive industrial plants throughout the nation where "Century" Corrugated Asbestos-Cement Sheets have been used for both roofing and siding.

The choice of "Century" Asbestos Corrugated is a logical one wherever quick application and maintenance-free service are desired. "Century" Asbestos Corrugated goes on quickly, inexpensively. The large-size sheets are exceptionally strong, but they can be cut and drilled easily—fastened in place with a minimum of labor.

And the protection is permanent! "Century" Asbestos Corrugated resists weather; *can not burn*, rot, or rust. Rodents and termites can't hurt it. It doesn't even need protective painting to preserve it!

Whatever your building plans—new construction, modernization, expansion—get the cost-saving story of "Century" Corrugated Asbestos-Cement Sheets. We'll gladly send complete data on request.

Nature made Asbestos...
Keasbey & Mattison has made it serve mankind since 1873

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IT ALWAYS PAYS TO SPECIFY

LADISH

Controlled Quality

PIPE FITTINGS

...to be sure of sound welds and fast assembly

Ⓛ TO MARK PROGRESS

Keeping welding costs down to a minimum and erection schedules on time... these are important advantages you can assure to any piping job by installing Ladish Controlled Quality fittings. Metallurgical controls over materials and methods provide an assurance of uniform weldability in every Ladish fitting... and thorough inspection to rigid standards of physical dimensions and geometric accuracy assures fast piping assembly.

THE COMPLETE *Controlled Quality* FITTINGS LINE
PRODUCED UNDER ONE ROOF...ONE RESPONSIBILITY

LADISH CO.

CUDAHY, WISCONSIN
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District Offices: New York • Buffalo • Pittsburgh • Philadelphia • Cleveland • Chicago • St. Paul
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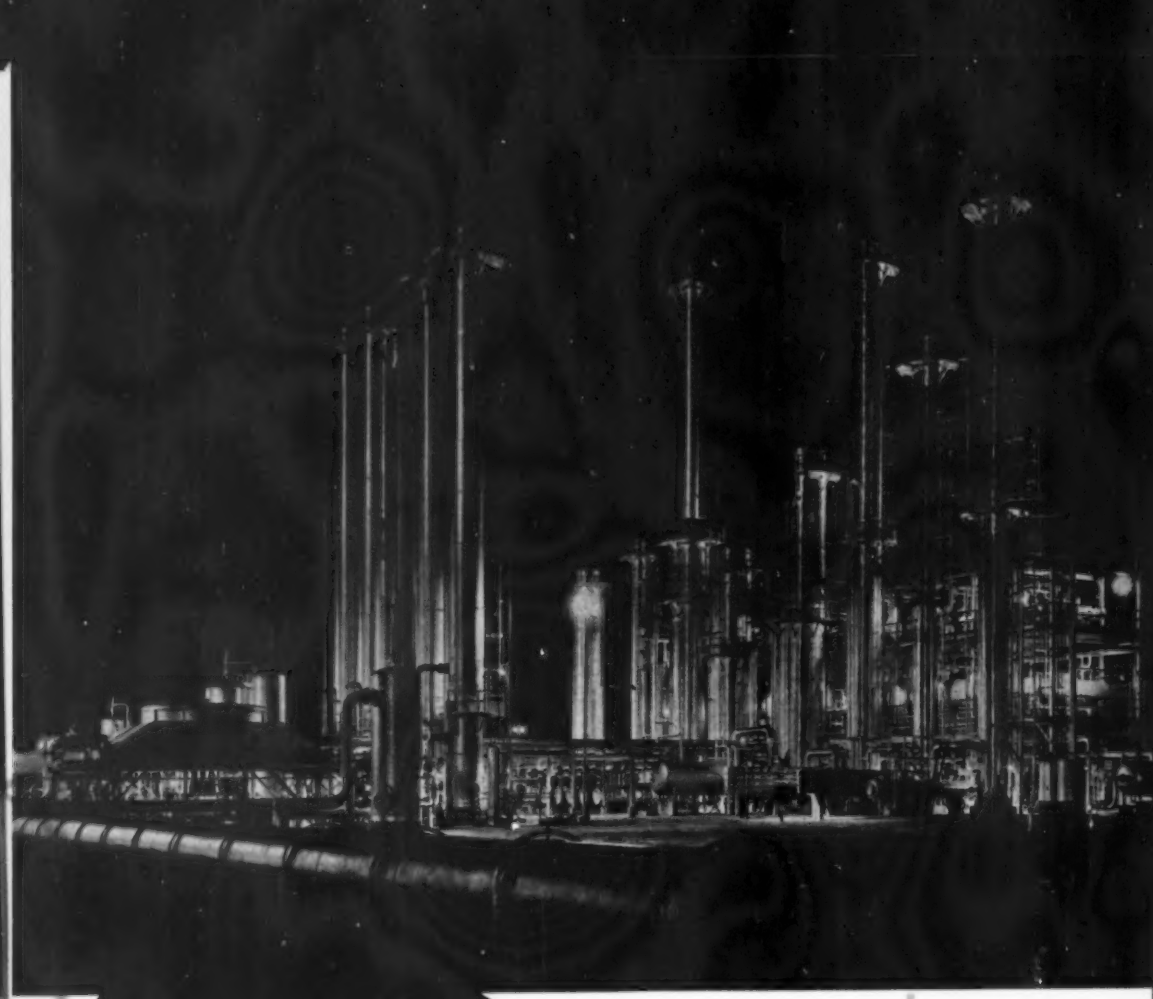

Thru the night . . . and the day

and year after year — high pressure gas will be delivered from this plant to cross-country gas pipe lines. The plant units to compress the inlet gas, remove hydrogen sulphide, extract and fractionate substantially all propane and heavier hydrocarbons, and remove water vapor from the remaining gas are integrated in process design, in lay-out, and in execution of detail to produce a smoothly functioning complete plant requiring minimum maintenance and operating expense.

This plant, designed and constructed for Gulf Oil Corporation to process gas from several fields in the Eunice area of Lea County, New Mexico, adds another major installation to the background of experience which has built the HUDSON reputation for complete dependability.

HUDSON
ENGINEERING CORPORATION
FAIRVIEW STATION • HOUSTON, TEXAS

CONCENTROL STOPS FOAMING

BEFORE

Laboratory demonstration shows foaming of highly alkaline solution in test cylinder.

This laboratory demonstration shows — as do scores of successful installations — that Bird-Archer's Concentrol is a highly effective anti-foam agent. It quickly stabilizes alkaline boiler water . . . eliminates foaming action and carryover. With Concentrol, you can forget about bouncing water gages. You get good quality dry steam every hour of every day.

Concentrol is available in liquid, powdered or briquette forms. Special Concentrol formulations are also available containing other commonly used boiler water treatment chemicals such as tannins, phosphates, alkalies, sulfite, etc.

See for yourself how economical Concentrol helps improve steam quality. Your Bird-Archer representative will demonstrate Concentrol in your plant . . . make specific recommendations for its use. Consult him, or write direct to Bird-Archer, outlining the details of your boiler operation.

FREE DATA SHEET AVAILABLE

HOW CONCENTROL WORKS

Concentrol works by effecting a rapid change in surface tension of steam bubbles which permit coalescence of small steam bubbles into bubbles of larger sizes. This results in the formation of unstable bubble films which break readily upon reaching the steam disengaging surface of the boiler water. This does away with foam build-up and subsequent carryover.

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WATER TREATMENT

THE BIRD-ARCHER COMPANY

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IN CANADA

The Bird-Archer Co., Limited

503 McGill Building, Montreal, Canada

IN MEXICO

Calderas y Accesorios, S. A.

Amsterdam 291, Mexico D. F.

BA 169

AFTER

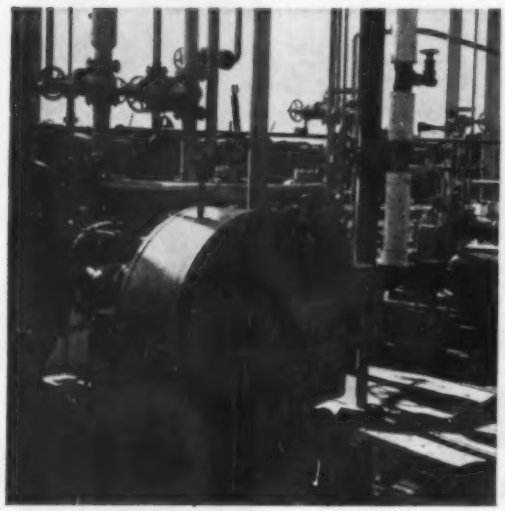
Same solution after addition of 12 ppm of Concentrol Anti-foam. Constant heat conditions were maintained during test.

WHY STANDARD DP TURBINE DRIVES FIT ALMOST ANY APPLICATION

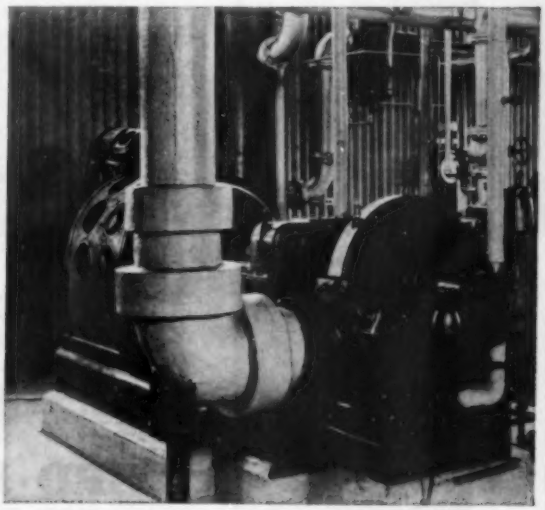
Here's a turbine designed by turbine users. It incorporates the features asked for by hundreds of operators interviewed in an exhaustive survey. They told General Electric they wanted a mechanical-drive turbine that would fit many types of applications—continuous process, standby, indoor, outdoor, equipment drive, generator drive, etc.

The DP answers these varied requirements with special features that are included as standard parts. For instance, you get hydraulic governing to meet critical accuracy requirements, totally enclosed construction that allows installation in hazardous atmospheres, pressure lubrication for dependable, continuous operation. These advantages are included at no extra cost—the DP is priced as a standard.

If you have steam available, the DP turbine can work profitably for you. You'll discover how its standard design gives you wide application flexibility, makes possible real savings in maintenance costs. The DP's operating record proves its reliability when there's a tough job to be done.



OUTDOOR INSTALLATIONS—No need to make special modifications when you move a DP out of doors. Totally enclosed governing system operating in its own oil atmosphere eliminates possibility of rusting or corrosion. You can operate a DP in hazardous atmospheres. Positive acting, non-sparking emergency governor protects the DP turbine against overspeed.



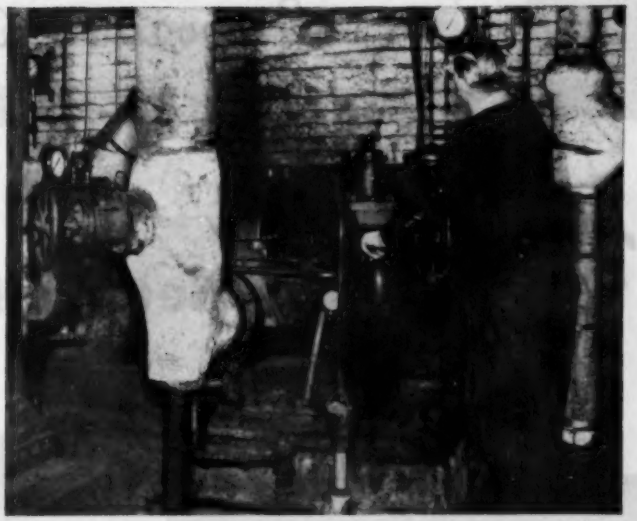
PRECISION GOVERNING—accurate enough for generator drives—is yours with the DP's hydraulic system. Regulation is 6 per cent with a 30 per cent range of speed adjustment. For process governing, regulator control is available.

Ask your General Electric representative for full details about the DP mechanical-drive turbine, or write for bulletin GEA-4955. General Electric Company, Schenectady 5, New York.

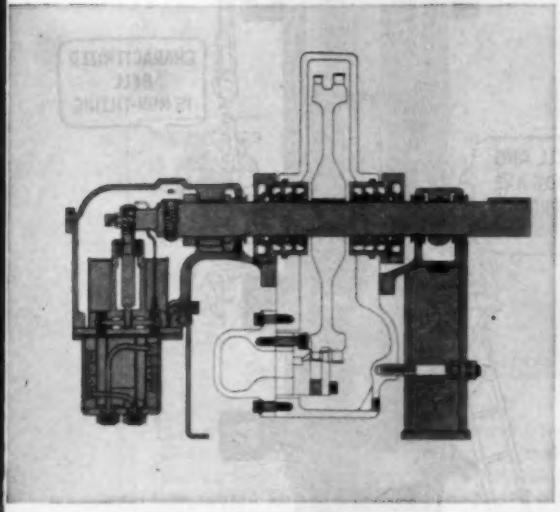
GENERAL ELECTRIC

252-50

MECHANICAL-DRIVE TURBINES



DEPENDABILITY is built into the DP. Positive lubrication through automotive-type bearings adds years to the life of the turbine. Special steel nozzle plate, self-lubricating graphite packings, and Monel-sprayed shaft are examples of design features that spell reliability.

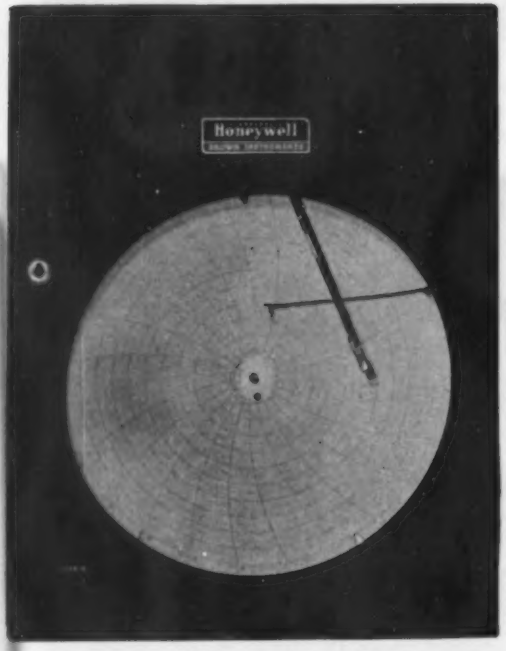


APPLICATION FLEXIBILITY As the shaded parts in the diagram illustrate, most DP parts are identical on all frame sizes and ratings. In this way, you can adapt a DP for different job requirements with only minor changes. A different nozzle plate gives you a new horsepower output. A change in governor gears provides a new speed range. DP's are rated from 10 to 1200 HP and 1000 to 5000 rpm, and with slight modification, can deliver up to 2000 HP and 10,000 rpm. During a change in plant operation, the DP's flexibility will save you money.

EASY MAINTENANCE Because most parts are interchangeable on all models, spares can be stocked at low cost. A spare parts kit, containing 91 items, can be obtained with the turbine. This simple method of stocking spares lowers maintenance costs and provides protection for several DP's in your plant. All models, regardless of frame size, horsepower, or speed ratings, have identical shaft height, keyways, and coupling fits. Thus, installation problems are simplified; you can move these center-line supported units from job to job without a custom line-up.

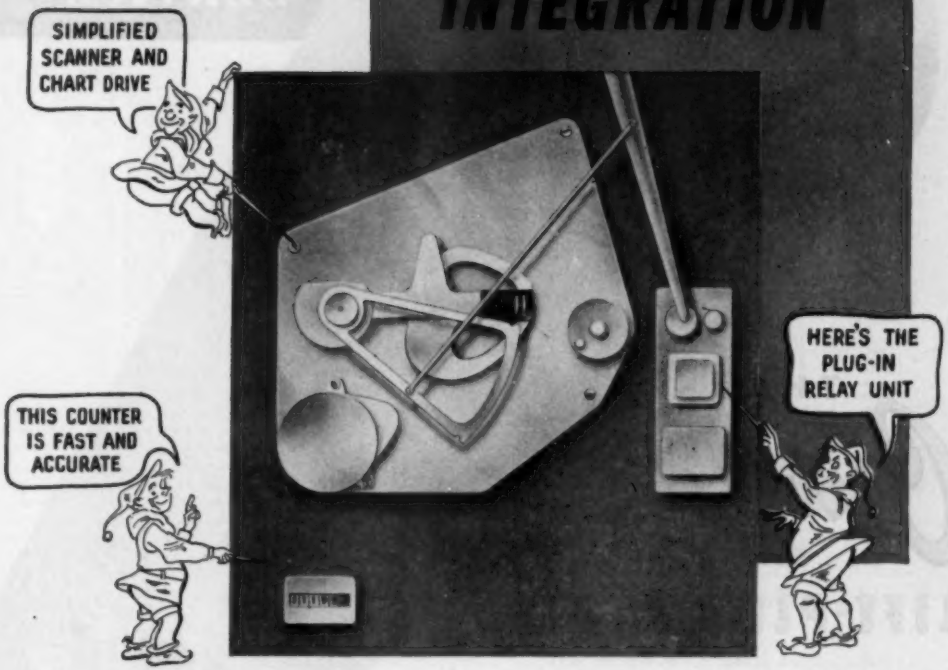
Important Contribution to

The New Brown Electric Flow Meter



EVENLY-DIVIDED CHART . . . provides uniform accuracy for all rates of flow. Write for new *Bulletin No. 293-1.*

incorporates . . . ELECTRONIC INTEGRATION



HERE's another important advancement for power and process instrumentation . . . continuous flow measurement, with electronic integration! This Honeywell development eliminates intermittent measurement and slow, complicated totalizing . . . welcome news to process engineers and accountants.

The electronic integrator, consisting of but three major parts, simplifies accessibility and maintenance . . . permits quick checking and calibration. Scanning is rapid and extremely simple. The corrosion resistant meter body is of tubular construction, reducing weight and bulk. Transmission is electric, recorder is fast, chart is easily read under all conditions of flow. The characterized bell is corrosion resistant, too, and is specially designed to eliminate tilting.

Call in our local engineering representative for a discussion of your application.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4498 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS **Honeywell**

Brown Instruments

THE VALVE THAT WAS DESIGNED FOR

PETROLEUM CHEMICAL SERVICE

THE

Cameron

NON-LUBRICATED

LIFT-PLUG VALVE

Originally designed for acid and light hydrocarbon service and first tested and proved in one of the nation's largest wartime alkylation units, the Cameron valve has since distinguished itself in all sorts of difficult petro-chemical services—chlorine, caustic, ammonia, gas distillate, ethylene oxide, butane, propane, molten sodium, oilfield and others.

The Cameron Non-Lubricated Lift Plug Valve combines the best features of gate and plug valves with a number of new mechanical innovations. Test it in your most difficult service. See for yourself how easily it operates and how tightly it seals, yet it requires no lubrication. Consequently the possibility of product contamination and clogging of metering equipment is eliminated. No periodic maintenance. No lubrication expense.

A descriptive booklet will gladly be sent to interested operators on request.

Cameron IRON WORKS, INC.

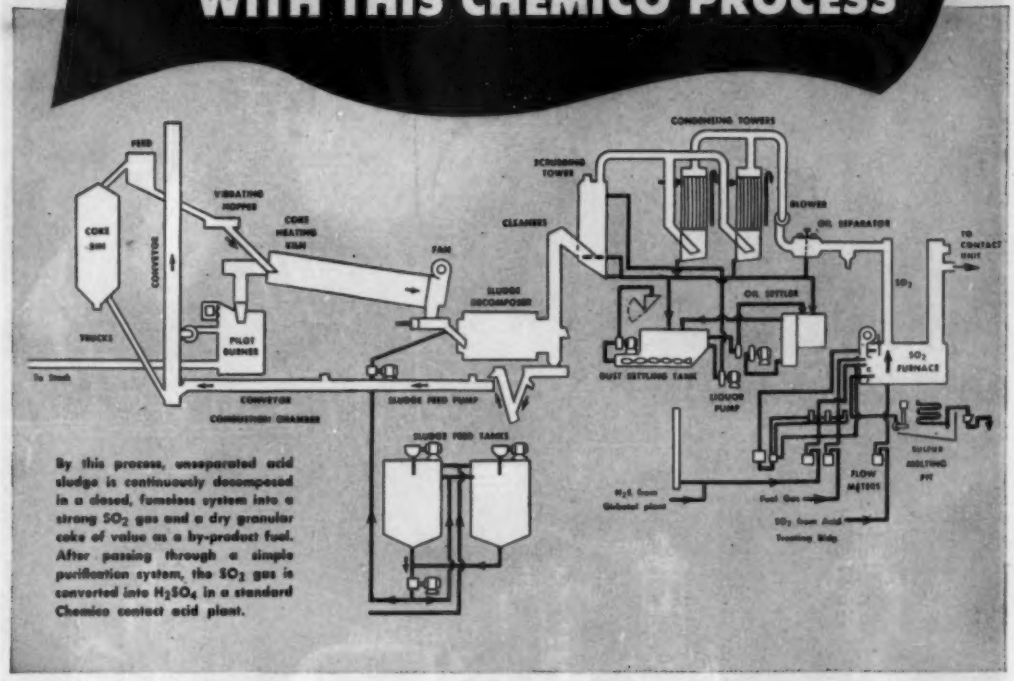
P. O. Box 1212 Houston, Texas

Export: 74 Trinity Place, New York, N. Y.

Represented in the sterling area by: British Oilfield Equipment Co., Ltd., Duke's Court, 32 Duke Street, London, S. W. 1.

Make Sulfuric Acid from Refinery Sludge

WITH THIS CHEMICO PROCESS



By this process, unseparated acid sludge is continuously decomposed in a closed, fumeless system into a strong SO_2 gas and a dry granular coke of value as a by-product fuel. After passing through a simple purification system, the SO_2 gas is converted into H_2SO_4 in a standard Chemico contact acid plant.

With the increasing shortage of raw sulfur, industry is turning to other materials which can be used for making much-needed sulfuric acid. An important source—waste oil refinery sludge—can be converted into clean sulfuric acid of any desired strength by the Chemico process shown in the flow diagram.

This proved and practical process offers three important advantages. (1) The purified SO_2 gas provides a product acid that is free of carbon contamination. (2) The resulting H_2SO_4 may be 98% or any higher strength regardless of the initial strength of the sludge. (3) Sludges that cannot be processed by other methods may be satisfactorily used in this system.

CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

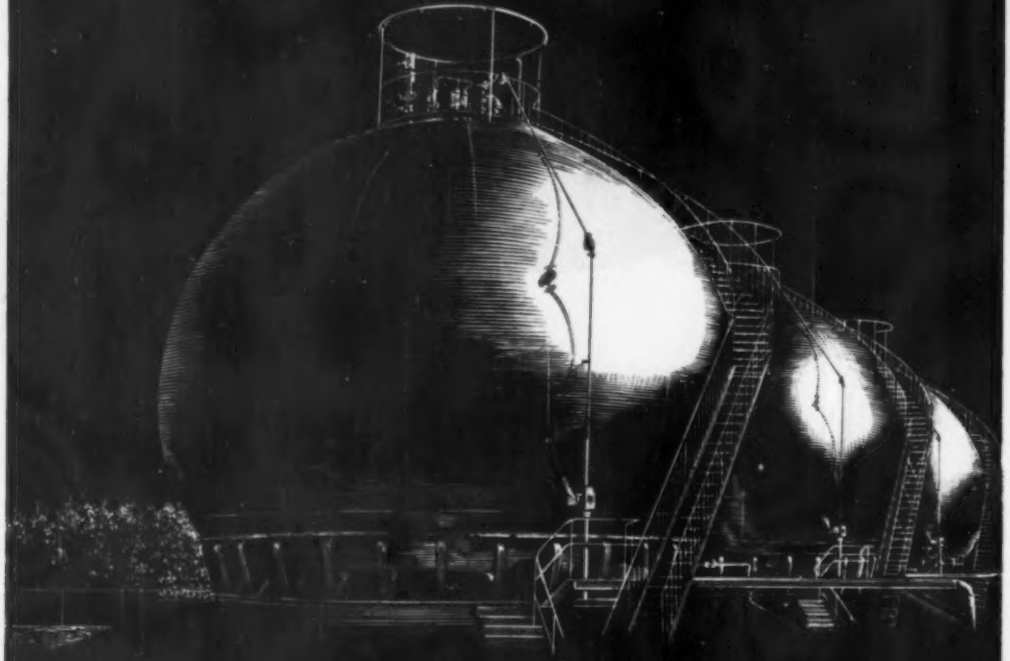
488 MADISON AVENUE, NEW YORK 22, N. Y.

EUROPEAN TECHNICAL REPRESENTATIVE: CYANAMID PRODUCTS, LTD., LONDON W. C. 2, ENGLAND
CABLES: CHEMICONST, NEW YORK

CHEMICO

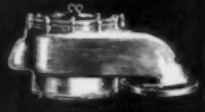
Chemico plants are profitable investments

Fittings for Hortonspheroids...



Semi-Automatic Tank Gauge and Sampling Lock, Fig. ST-3320 "DLB." Can be used for sampling and temperature thiefing. It is mounted here on S&J's Quick Opening Gate Valve, Fig. TT-135 which can be opened or closed with only half the number of turns required by other valves.

Pilot Operated Safety Relief Valve, Fig. ST-2500. Designed to protect tanks from excessive internal pressure. One pilot valve can serve one, two, or more main valves to meet high venting requirements. Main valve pallet is seated under pressure to moment of venting. This valve requires no great excess pressure for full venting capacity.



Vacuum Breather Valve, Fig. ST-1926. Designed to meet the unusual vacuum breathing requirements of pressure storage tanks, and to withstand high internal pressures when not in operation under a vacuum. This valve is automatically self draining, and utilizes a hinge type pallet.

High Pressure Automatic Tank Gauge, Fig. ST-400, will consistently and accurately measure product depths. Features new Safety Closure to protect extra thick Safety Glass. Gauge greatly reduces time required to measure tank contents accurately, because it can be installed at eye level height.

Shand and Jurs Co. 8TH AND CARLTON STREETS : BERKELEY : CALIFORNIA

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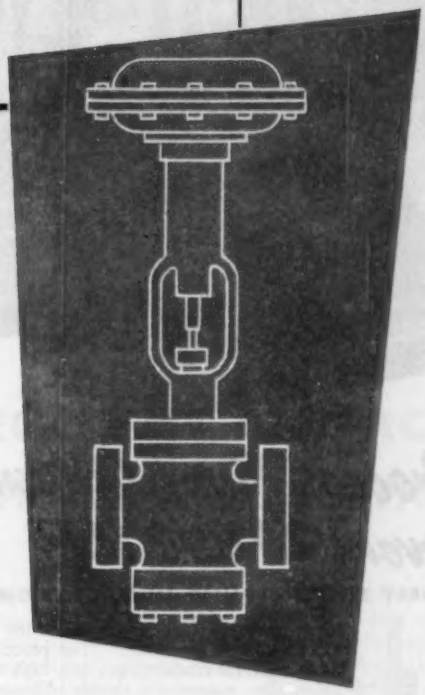
MONTREAL, QUE., 360 Notre Dame St. West VANCOUVER, B. C., 550 Beatty St. FORT ERIE, ONT. DARLINGTON, ENG. CARACAS, VEN.

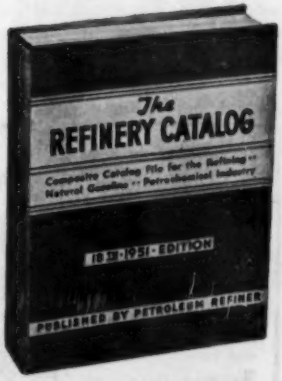
12 Pressure Controller
MANUFACTURERS HAVE THEIR CATALOGS FILED IN REFINERY CATALOG



***Comparing* is easier**

YOU don't play blindman's bluff whenever you buy or specify gas process plant equipment . . . you look around, you compare. When you need to compare pressure controllers or any of approximately 2,000 other types of refinery, natural gasoline or petrochemical plant equipment reach for your copy of Refinery Catalog. You'll find catalog data on equipment made by more than 300 leading manufacturers.

Compare process equipment quicker, easier—look it up in Refinery Catalog.



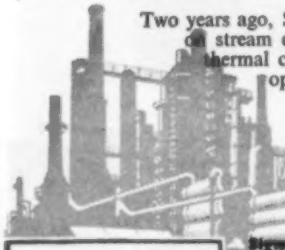
REFINERY CATALOG

THE UNIVERSAL EQUIPMENT GUIDE FOR REFINERY BUYERS

Shell Repeat Order for Sigmund Pumps!

Process Pump Output -over 20,000 H.P.

BIGGEST PROCESS PUMP INSTALLATION EVER DESIGNED AND MADE IN BRITAIN



Two years ago, Shell commissioned the first distillation unit at Cardon, Venezuela and it has been on stream ever since. The process pumps operating in this distiller — along with units for thermal cracking, gas tail, high vacuum and other sections of the refinery, which went into operation shortly afterwards, were supplied by Sigmunds.

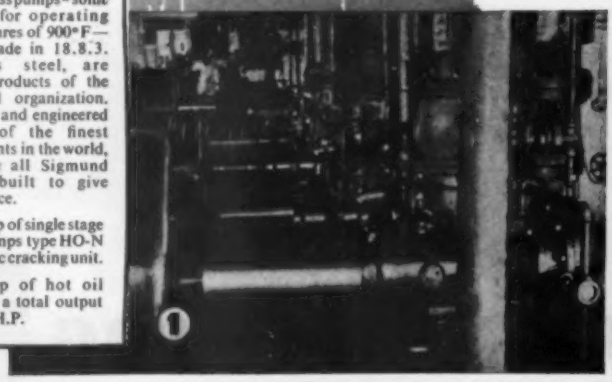
Now the second distillation unit has been put in hand, and once more Sigmund are to be responsible for the pumps. This new contract raises the total of Sigmund pumping equipment at the Cardon refinery to over 20,000 h.p., in a plant which will have an intake of crude oil in the region of 140,000 barrels a day when the additional distillation unit is completed — sufficient to provide over a third of Britain's requirements of petroleum products.

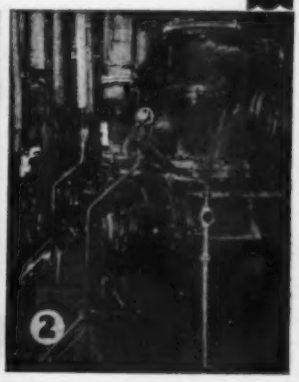
Sigmund Pumps Ltd., Terminal House, 52, Grosvenor Gardens, London, S.W.1.

The process pumps - some of them for operating temperatures of 900°F — others made in 18.8.3. stainless steel, are typical products of the Sigmund organization. Designed and engineered in one of the finest pump plants in the world, and, like all Sigmund pumps, built to give real service.

1. Group of single stage slurry pumps type HO-N in catalytic cracking unit.

2. Group of hot oil pumps of a total output of 3,000 H.P.





New York address: 30 Church St., 7, N. Y. Tel.: Worth 4-3396

NEW from GARLOCK

Packings and Gaskets made of Teflon*

*Teflon is the Du Pont Company's trademark for tetrafluoroethylene resin.

The Packing and Gasketing Material that

IS ENTIRELY UNAFFECTED BY ANY ACID, ORGANIC SOLVENT OR ALKALI SOLUTION

GARLOCK 8764 . . . *a rod, shaft or flange packing made of* Teflon *powder molded to required size and shape. Available in ring, sheet, gasket, tape, disc or cup form. Also used for making envelopes for gaskets.*

GARLOCK 5733 . . . *a "Lattice-Braid" rod or shaft packing made of* Teflon *filament. Supplied in coil or ring form.*

GARLOCK 9168 . . . *a plastic rod or shaft packing made of shredded* Teflon. *Supplied in coil or ring form.*

Exhaustive tests in the GARLOCK laboratories and in the field have proved that *Teflon* is the only *wholly* satisfactory material for sealing against acids, organic solvents, and other chemicals.

GARLOCK packings and gaskets made of *Teflon* are entirely unaffected by acids and are completely resistant to all organic solvents and alkali solutions. They are suitable for use at operating temperatures from below −90° F. up to 500° F. Within that temperature range these packings and gaskets *retain* their inherent toughness, have a *low* coefficient of friction, and do *not* react with metals of construction.

Wherever resistance to chemicals is a *requisite*, specify GARLOCK'S *Teflon* packings for use on valves, pump rods or shafts and *Teflon* gaskets for all types of flanged joints.

Write for this new Catalog!

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

Tulsa, Okla. Houston, Texas Los Angeles, Calif.

GARLOCK

ALCOA Activated *Alumina dries to lower dew points than other commercial adsorbents

ALCOA *Activated* Aluminas are among the most effective and efficient desiccants available for the dehydration of liquids and gases. Dew points as low as *minus* 100° F.—and even lower—may be obtained, and under normal circumstances, ALCOA *Activated* Aluminas can be used for an almost indefinite number of drying cycles.

*Reg. T.M. Aluminum Company of America

ALCOA *Activated* Aluminas have high resistance to crushing, shock and abrasion . . . do not soften, swell or disintegrate, even when immersed in water . . . are non-toxic . . . non-corrosive . . . . high in purity . . . practically iron free.

Besides their use for dehydration, ALCOA *Activated* Aluminas adsorb certain gases and vapors from gaseous mixtures and serve as catalysts and catalyst carriers. They are used in the liquefaction of gases, and for the maintenance of transformer and lubricating oils.

Let us tell you more about these efficient, solid-type desiccants. Write to: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 617F Gulf Building, Pittsburgh 19, Pennsylvania.

Alcoa Chemicals

ALCOA

ALUMINAS and FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • HYDRATED ALUMINAS • TABULAR ALUMINAS • LOW SODA ALUMINAS ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE • GALLIUM

Are you a plans man?

...or a process man?

Whichever you are, it pays to make full use of **NATIONAL** *service on* **LEAD EQUIPMENT**

Whether you're in planning or production...you can save yourself time and expense by using NATIONAL service on lead equipment in any form: separators, agitators, all types of tanks and vessels.

By using NATIONAL service, you make sure of two important things...

You make sure your equipment is properly *designed.* NATIONAL's Engineering Department has specialized for many years in the development of acid-handling equipment for numerous branches of the chemical field.

You make sure your equipment is properly *fabricated.* NATIONAL's "Homogeneous" process of bonding lead to steel gives you positive assurance that the lead lining won't creep, buckle, or lose its grip. As the leader in lead, NATIONAL knows the problems involved in building all types of processing equipment to specifications... and has the know-how needed to solve these problems.

When you need lead-lined or lead-covered equipment for handling corrosive chemicals... when you need any other lead product... be sure to take full advantage of NATIONAL service.

*Reg. U. S. Pat. Off.

NATIONAL LEAD COMPANY

New York 6; Atlanta; Baltimore 3; Buffalo 3; Chicago 8; Cincinnati 3; Cleveland 13; Dallas 2; Philadelphia 25; Pittsburgh 12; St. Louis 1; Boston 6 (National Lead Co. of Mass.); Los Angeles 23 (Morris P. Kirk & Son, Inc.); Toronto, Canada (Canada Metal Company, Limited)

FACTS ABOUT THE NEW *Microsen*

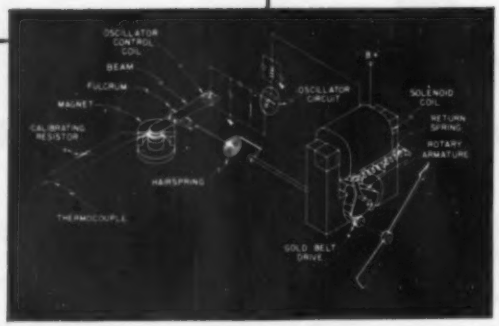
TEMPERATURE MEASURING INSTRUMENTS

Conventional industrial temperature measuring devices, like millivolt pyrometers and potentiometers, are often too fragile, complicated or costly for many applications.

Microsen Temperature Indicators and Recorders have none of these disadvantages, whatever the demands of service. They are rugged, simply constructed, economical – yet measure temperature precisely between –100° and + 3000°F.

Heart of the instrument is the power-actuated Microsen Balance, a unit extremely sensitive to low power input–insensitive to line voltage variations. Both dials and charts are readily calibrated to thermocouple temperature scales. Thermocouple cold junction compensation is achieved–regardless of ambient temperature effects–by a built-in, thermostatically-controlled and insulated heater. A sealed housing protects all measuring elements from dust and corrosive vapors.

The high torque rotary solenoid, which drives the pointer, makes the instrument especially suitable for round dial indication, thus reducing the opportunity for parallax error. It also assures "pin point" accuracy in positioning the pointer, and permits the use of dials as large as 12 inches.



HOW MICROSEN INDICATORS AND RECORDERS MEASURE TEMPERATURE

The Microsen Balance maintains equilibrium between two forces. One is proportional to thermocouple input, the other to the mechanical position of the instrument pointer.

Any change in thermocouple input deflects the Microsen beam and changes the proximity of the beam's flag end to the oscillator coil. The oscillator circuit then detunes and creates a current change through the vacuum tube and solenoid coil.

As the solenoid armature rotates, it positions the pointer so that the hairspring torque is opposed and equal to the input torque. The mechanical indication is thus weighed in exact proportion to thermocouple input. Consequently, the pointer accurately indicates the temperature on the dial.

MICROSEN BULLETIN 404 contains details about these revolutionary new temperature measuring instruments. Also included is information about Microsen Electric Indicators and Recorders for other fields of measurement. Write for a copy.

1942 MICROSEN U.S.A.

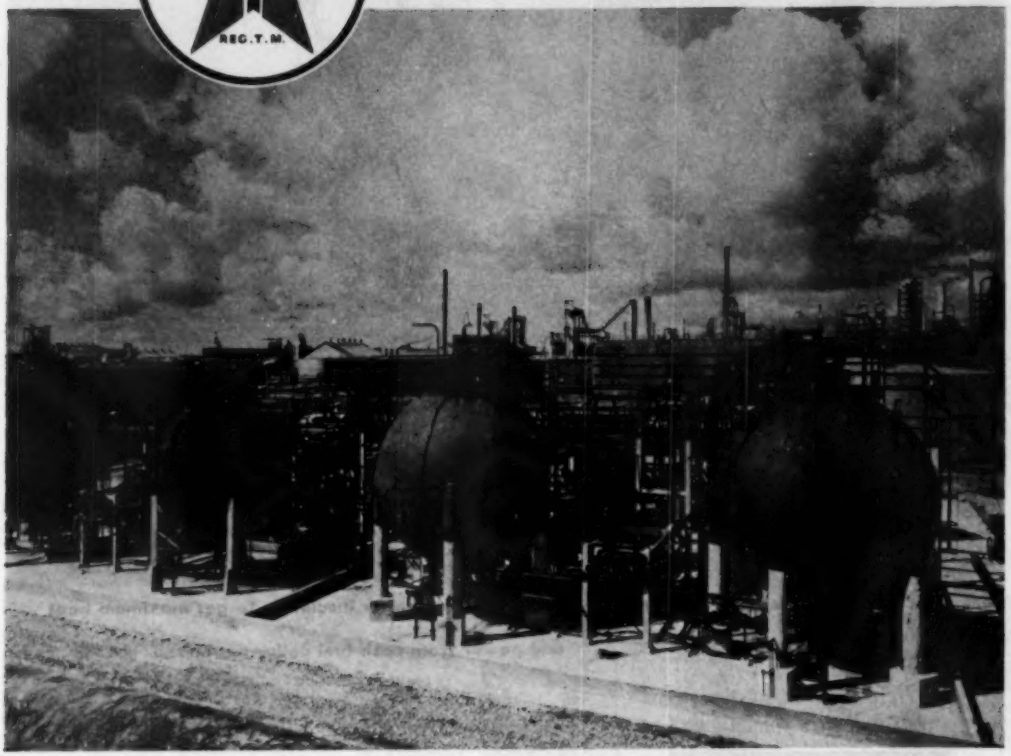
MICROSEN ELECTRICAL INSTRUMENTS

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'MICROSEN' ELECTRICAL AND 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES. BUILDERS OF "SHAW-BOX" CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

TEXACO
REG. T. M.

another leading refiner who desalts with PETRECO



Illustrated above is one of the largest batteries of Petreco Electrospheres in the world. This installation is located at the Port Arthur, Texas, refinery of The Texas Company. In refinery after refinery, Petreco Desalters have proved their pay-out by increasing on stream time, increasing expected unit throughputs and by reducing maintenance and repair costs. These advantages derived from charging desalted crudes also entail benefits such as reduced furnace plugging, longer tube life, maximum exchanger efficiency, less corrosion in the topping section, clear water bleed, salvaged waste oil and trouble-free, automatic desalter operation. For the best in desalting performance and service, get Petreco.

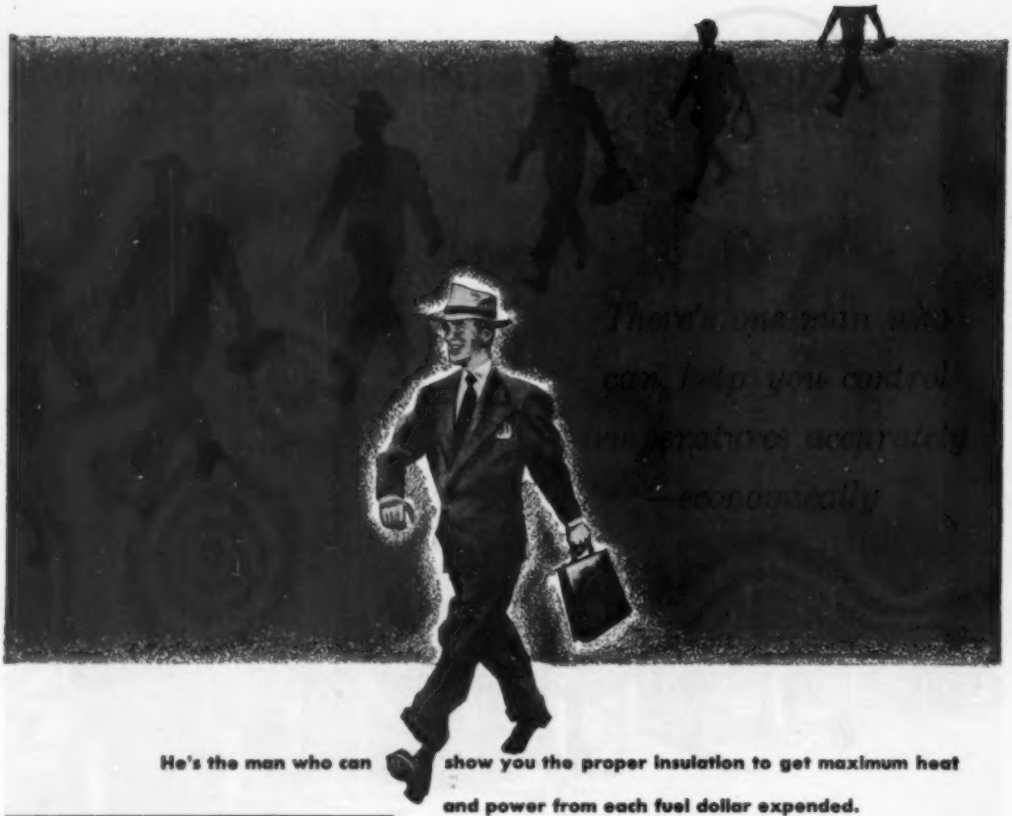
PETROLEUM RECTIFYING COMPANY | 5121 South Wayside Drive, Houston 3, Texas
1390 East Burnett Street, Long Beach 6, California

PETRECO OFFERS COMPLETE DESALTING SERVICE AND FACILITIES

PETRECO

SPECIALIZED *Electric* PETROLEUM PROCESSES { DESALTING / DEHYDRATING

PR 51-4



He's the man who can show you the proper insulation to get maximum heat and power from each fuel dollar expended.

Here's one insulation that will save you money

EAGLE-PICHER SUPER "66" INSULATING CEMENT

Super "66" is all-purpose, rust-inhibitive, extremely adhesive insulating cement. "Springy ball" pellets don't collapse after application . . . give great coverage, retain their thermal efficiency. 100 lbs. covers 65 sq. ft.—1 inch thick! Easily applied with trowel, over flat and irregular surfaces. Efficient for temperatures up to 1800°F. Reclaimable when used on equipment whose temperatures do not exceed 1200°F.!

An Eagle-Picher Industrial Insulation distributor or representative can help you reduce operating expenses because he has available a wide line of insulation products—for high and low temperatures—scientifically designed for maximum thermal efficiency, and practical application. Why not let him give you more information about some of the products listed here?

These Eagle-Picher products can save you money . . . power . . . time

Insulating Felts • Supertemp Blocks • Blankets
Loose Wool • Pipe Covering • Stalastic • Insulseal • Insulstic
Swetchek • Finishing Cements • Insulating Cements
Fireproofing Cement • Diatomaceous Earth Blocks

THE EAGLE-PICHER COMPANY

General Offices: Cincinnati (1), Ohio

Insulation products of efficient mineral wool—for a full range of high and low temperatures. Technical data on request.

EAGLE EP PICHER

Since 1843

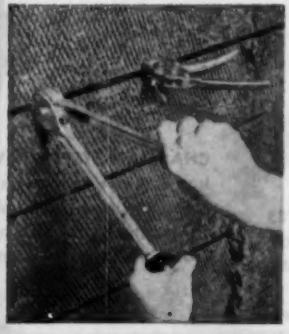
2100 • 2104

Get maximum fuel savings and exact temperature control with these versatile, efficient insulations

For a completely effective, low-cost insulation combination, you can't beat the teamwork of Eagle-Picher Mineral Wool Blankets, Supertemp Blocks, Super "66" Insulating Cement, No. 106 Fireproofing Cement and Insulseal. They work effectively to give your equipment highest possible thermal efficiency . . . cut operating costs by saving maximum amount of fuel . . . and help to provide perfect, precise control over temperatures.

EAGLE-PICHER FIREPROOFING CEMENT

Mixed with water to form a stiff plastic mix for easy application on ribbed lath. Recommended for fireproofing structural steel columns, steel tank supports, skirts and equipment bases. Has high dry coverage of approximately 30 sq. ft. 1 inch thick per 100 pounds. Adds fire protection, patented rust-inhibitor resists corrosion. Tested by Underwriters' Laboratories, Inc.



EAGLE-PICHER MINERAL WOOL BLANKETS

These blankets satisfy the need for a convenient method of quickly and efficiently insulating flat or curved surfaces on larger types of heated equipment. Mineral wool is felted and secured between flexible metal fabric. Outstanding physical and chemical stability enables Eagle-Picher Blankets to resist water, steam, corrosive fumes and normal vibration.

EAGLE-PICHER SUPERTEMP BLOCKS

Eagle-Picher Supertemp Blocks are lightweight (approximately 16 lbs. per cu. ft.). Can be cut easily with knife or saw to fit off-shaped areas . . . they fit snugly over minor irregularities. They're strong and have high refractory value. Withstand temperatures up to 1700° F. Conductivity at 512° F. approximately 0.43 . . . all standard sizes, from 3" x 18" to 12" x 36" . . . in thicknesses from 1" to 4".

EAGLE-PICHER INSULSEAL

A tough, weatherproof, protective coating for insulation. For temperatures up to 450° F. Applied as a plastic, its smooth troweling qualities assure uniform coverage, proper thickness. It protects insulation from air infiltration, fumes, rain, snow, vibration, punctures, and withstands severe service, indoors or out. Dries to a smooth, rich black, has a neat appearance on hot or cold surfaces . . . may be washed or painted.

THE EAGLE-PICHER COMPANY General Offices: Cincinnati (1), Ohio

Insulation products of efficient mineral wool—for a full range of high and low temperatures. Technical data on request.

EAGLE EP PICHER *Since 1843*

CHAPMAN

Steel Valves Score on all 3 Points

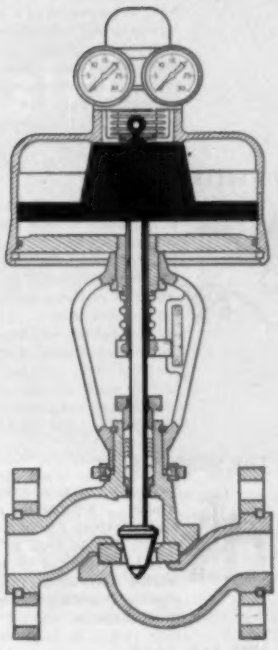
1
CHAPMAN STEEL VALVES have the high precision ratings of custom-made valves — but the economy of production-line manufacture.
2
CHAPMAN STEEL VALVES are made exclusively from quality-controlled steels developed and produced in Chapman's own foundries under control of Chapman's own outstanding metallurgists.
3
CHAPMAN STEEL VALVES are designed to equal or surpass — A.S.A. and A.P.I. Standards in all pressures and temperature ranges.

Be sure to see Chapman first whenever you need steel valves — gate, globe, angle or check. As a result of Chapman's long years of research and experience, they are tops in every respect.

The Chapman Valve
MANUFACTURING COMPANY
INDIAN ORCHARD, MASS.

Powerful Control Action...

DOESN'T FIGHT SPRINGS



UTILIZES ALL THE FORCE

• The ANNIN Domotor positively and precisely controls hard-to-handle fluids under all types of conditions. The valve plug is positioned in both directions by over one ton of force—all available power is used to positively position the single seated valve plug. Write today for complete information.

FEATURES:

- SINGLE SEATED CONSTRUCTION for positive tight shutoffs.
- MINIMUM PISTON DISPLACEMENT for maximum operating speed.
- UNLIMITED VALVE TRAVEL for more accurate control.
- POSITIVE ACTION BOTH WAYS assures dependable operation under all conditions.
- BUILT IN POSITIONER eliminates cumbersome external weight of conventional valves.
- UNLIMITED POWER—any amount obtainable by increasing operating pressure.
- LIGHT WEIGHT—Less than ½ the weight of conventional valves.

REMEMBER—Teflon Chevron packing has been standard equipment on all Annin Valves for over two years.

ANNIN DOMOTOR VALVES

THE ANNIN COMPANY 3500 Union Pacific Avenue, Los Angeles 23, California

Building Strength for the Free World

*Highlights from the Annual Report of Standard Oil Company (New Jersey)**

for 1950... a year of record activity

Standard Oil Company (New Jersey) is an American corporation which has, in varying degrees, investments of capital and technical knowledge in a large number of operating oil companies, both in the United States and abroad. In 1950, these companies:

IN THE U. S. A.

Drilled over a thousand new wells, with an unusually high proportion of producers . . . Improved and expanded refineries in New Jersey, Maryland, Louisiana, and Texas . . . Completed a new continuous wax-making plant at Bayonne, N. J. . . . Added 370 miles to Texas crude oil pipeline systems . . . Started doubling the capacity of a products pipeline across Pennsylvania . . . Let contracts to increase by 85% the capacity of a pipeline from Baton Rouge to the Southeastern states . . . At government request, re-activated two government-owned Butyl rubber plants; also continued operating two others which have been producing constantly since 1943 . . . Invested over 20 million dollars in laboratory research for new and improved processes and products.

IN WESTERN EUROPE

Proposed a plan which ended gasoline rationing in England . . . Went ahead of schedule in construction of a new refinery at Fawley, England, to be the largest in Europe . . . Expanded, improved or started construction of refineries in Norway, Belgium, West Germany, France, and Italy . . . Opened many new service stations, which served not only local motorists, but some 18,000 American tourists . . . Supplied 28% more fuel oil than a year ago, to meet needs for industrial expansion . . . Met the greatest demand for asphalt for new road building ever experienced in these areas.

IN THE MIDDLE EAST

Stepped up oil production substantially in Saudi Arabia . . . Opened the vitally important Trans-Arabian Pipeline system from oil fields on the Persian Gulf to the Mediterranean . . . over 1,000 miles of 30- and 31-inch pipe . . . Started construction of a large-diameter pipeline extending 550 miles from Iraq to the Mediterranean.

IN THE FAR EAST

Expanded production of crude oil in Indonesia and explored for oil in Papua . . . Increased output of refineries in Australia, Sumatra, Japan.

IN CANADA

Produced nearly 50% more oil than a year ago . . . Made new oil and gas discoveries in Ontario and Alberta . . . Operated nine refineries at 14% greater output than a year ago . . . Opened a new 1,100-mile pipeline system from Alberta to Lake Superior, to carry crude oil toward the major Canadian refineries and markets.

IN SOUTH AMERICA

Set a new production record in Venezuela, second largest oil-producing country in the world . . . Operated the big Aruba refinery in the Netherlands West Indies at a higher rate than ever before . . . Met sharply increased call for products throughout the continent, to support the vigorous post-war development.

IN OCAN TRANSPORT

Received the last 4 of 12 super-tankers ordered two years ago . . . Ordered 6 more new tankers . . . Operated an ocean-going tanker fleet of 117 vessels, totaling over 2 million deadweight tons.

IN EMPLOYEE RELATIONS

Continued the same favorable labor relationships that have prevailed for more than three decades, with no strikes in domestic operations.

THE YEAR ENDED . . . THE JOB GOES ON. In 1950, for the first time, world use of oil outside the Iron Curtain passed 10 million barrels a day. For comparison, it was just over 7 million in 1945, the peak war year.

This is significant to free people everywhere. Oil supplies in today's world are closely linked to living standards and national strength.

It seems clear that more and more the world will look to oil to help keep it free and progressive. More and more it becomes clear, in meeting that need, that the American-developed business process of risk and result . . . of competition spurring corporate ingenuity and responsibility . . . is a strong and flexible system for promoting the welfare of people.

* We will be pleased to send a copy of the full report to anyone wishing it. Write Room 1626, 30 Rockefeller Plaza, New York 20, N. Y.

FINANCIAL SUMMARY

Standard Oil Company (New Jersey) and Consolidated Affiliates

Total income from sales, services, dividends and interest . . $3,198,266,000	Taxes collected for governments . . $294,749,000
Net income . . . $408,223,000 or $13.48 per share	Wages and other employment costs . . $548,205,000
Dividends . . . $151,028,000 or $5.00 per share	Spent for new plants and facilities . . . $295,132,000
Taxes paid . . . $276,000,000	Number of stockholder-owners 222,000
	Number of employees 116,000

STANDARD OIL COMPANY (NEW JERSEY)

AND AFFILIATED COMPANIES

another
LIMITORQUE
Advantage..

3 to 4 times faster

When power fails or any other emergency arises demanding manual valve operation LimiTorque Valve Controls prove their superiority again.

A positive, manual declutching lever disengages the motor driven worm gears and permits the handwheel to turn an independent set of bevel gears direct to the valve stem. This assures 3 to 4 times faster closing than is obtainable with other types of controls whose manual operations are all or in part through the main stem nut gearing. LimiTorque can always be declutched for handwheel operation regardless of weather or electrical conditions.

Remember—LimiTorques may be had for all types of valves and can be actuated by any available power source. Your valve manufacturer can supply them.

Write for the LimiTorque Catalog on your business letterhead, please.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON
IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

These tubes have service "built in"

CHASE ANTIMONIAL ADMIRALTY

(a patented alloy)

Since 1935, millions of pounds of Chase Antimonial Admiralty* tubes have been installed and are serving well. This testifies that they'll give you years of service, too.

These tubes resist dezincification because they have *enough* antimony. And because antimony doesn't affect grain structure, it will not weaken the tube.

Chase Antimonial Admiralty* stays tough . . . stands up under heavy duty. Send coupon for FREE book on Condenser and Heat Exchanger Tubes.

CHASE WAREHOUSE STOCKS:
NEW YORK, BALTIMORE, NEW ORLEANS, LOS ANGELES,
also carried by —
Vinson Supply Co., Tulsa
Standard Brass & Mfg. Co., Houston.

*U.S. Pat. No. 2,061,921

FREE CHASE BOOK discusses corrosion problems and selection of proper alloy for condenser and heat exchanger tubes.

Chase Brass & Copper Co., Dept. PR651
Waterbury 20, Conn.

Please send me Free Book on Condenser and Heat Exchanger Tubes.

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Chase BRASS & COPPER

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

• The Nation's Headquarters for Brass & Copper

Albany†	Cleveland	Kansas City, Mo.	New York	San Francisco
Atlanta	Dallas	Los Angeles	Philadelphia	Seattle
Baltimore	Denver†	Milwaukee	Pittsburgh	Waterbury
Boston	Detroit	Minneapolis	Providence	
Chicago	Houston†	Newark	Rochester†	(†sales office only)
Cincinnati	Indianapolis	New Orleans	St. Louis	

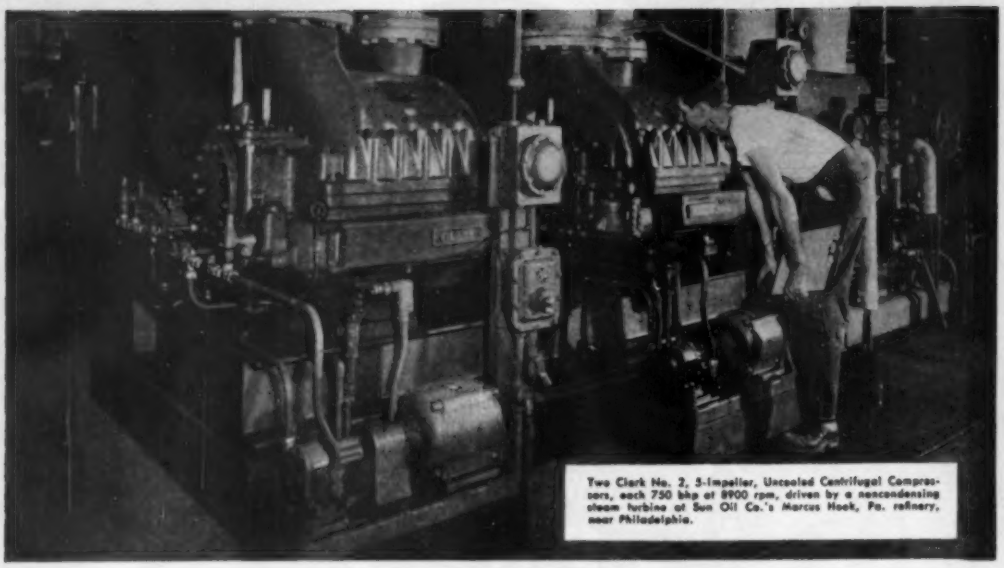
O·C·T NOW PROVIDES A DEPENDABLE SUPPLY OF
GUARANTEED QUALITY API RING GASKETS

Oil Center Tool . . . one of the recognized leaders in precision oil equipment manufacture . . . has recently equipped a completely new department for the exclusive manufacture of API "Soft Steel" Ring Gaskets. O-C-T API Ring Gaskets will be manufactured in a full range of sizes and pressures, produced to O-C-T's usual high standards—with the quality guarded and guaranteed by careful laboratory control. In addition, O-C-T API Ring Gaskets are micromatically inspected for assurance of true radius and close tolerance on pitch diameter. O-C-T Ring Gaskets are cadmium plated for extra protection against corrosion. Sealing surfaces are guarded against damage.

O-C-T Guaranteed Quality Ring Gaskets are now available through your regular sources of supply. Specify O-C-T Guaranteed Quality on your next order.

WRITE TODAY FOR YOUR FREE COPY OF THE O-C-T FLANGE DIMENSION BOOK; BASED ON API STANDARD 6B.

Oil Center Tool Co.



Two Clark No. 2, 5-Impeller, Uncooled Centrifugal Compressors, each 750 bhp at 8900 rpm, driven by a noncondensing steam turbine at Sun Oil Co.'s Marcus Hook, Pa. refinery, near Philadelphia.

UNIQUE APPLICATION BY SUN OIL'S MARCUS HOOK REFINERY

Conserves Energy, Cuts Costs

✓ In feeding air system network
✓ In reducing steam pressure

Wherever steam is available and space is at a premium, Clark Centrifugal Compressors have long been recognized as the ideal source of shop air. *That's a widely known fact!*

But, Sun Oil Company's refinery at Marcus Hook, Pa. had an additional and unique reason for recently installing two of these Clark units: They were most economically suited to the energy-conserving, cost-cutting system, which Sun had engineered, to accomplish in one continuous operation — (1) The feeding of the refinery air system network, and (2) The reduction of large volumes of steam from 400 to 135 psi pressure.

By using a noncondensing steam turbine to drive two Clark No. 2, 750 bhp (each), 5-Impeller, Uncooled Centrifugal Compressors, and simultaneously reduce the steam pressure, Sun has come out far ahead. Available steam is being utilized to economically serve air requirements (the unit compresses 6150 cfm of air from the atmosphere to a discharge pressure of 110 psig). Large losses of energy, inevitable with the use of a reducing valve, and high costs involved in the use of a boiler, have thus been avoided.

To be current on the economy of Clark Centrifugal Compressors for *your* plant, write for literature and consult with your nearest Clark representative.

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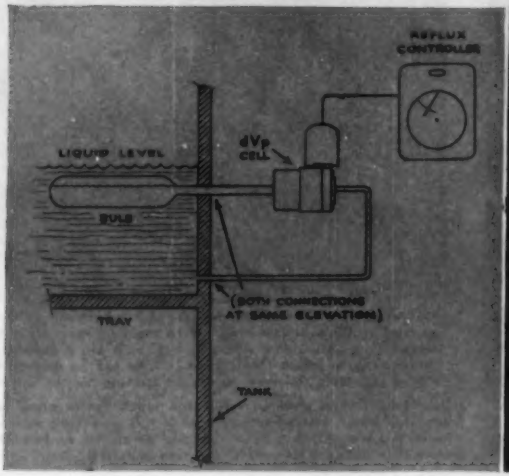

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This revolutionary development by Foxboro introduces new simplification in distillation processes. Automatically measuring and transmitting vapor pressure *differential*, it eliminates time-consuming laboratory analyses in fractionating tower operation . . . permits tapping off fractions of any desired vapor pressure, within precise tolerances, continuously and automatically.

In the dVp Cell, the vapor pressure at any specified point in the column is continuously compared with the vapor pressure of a sample of the material desired at that point. The sample is contained in a bulb immersed in the liquid. The dVp Cell measures the difference between the two vapor pressures and transmits this difference to an automatic controller on the process. Changes in temperature affect product and sample equally, and hence have no effect on the differential measurement.

Detecting small pressure differences accurately, the new dVp Cell is not injured by high unbalanced pressures. It uses no mercury, is compact and easy to install. Self-contained manifold permits quick, easy filling of sample bulb with the reference fluid without special equipment, and without disassembly of the cell.

Write for detailed information on this unique new Foxboro development. Inquiries concerning unusual or experimental applications especially invited. **The Foxboro Company, 746 Neponset Ave., Foxboro, Mass., U.S.A.**

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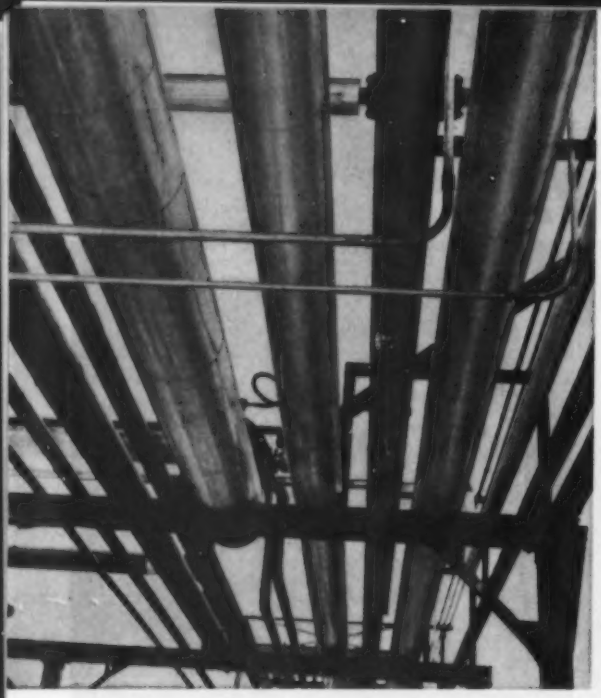
INSTRUMENTS



This close-up clearly shows the ribs or corrugations which add strength to Childers Jacketing and also make it form more easily around lines. Aluminum strapping and seals are a quick, inexpensive way to attach the jacketing. They can be used without any special tools and take no special training for the installers.

Does long lasting aluminum cost too much for covering your insulated lines? Not when you specify this new type weatherproof jacketing. It has been specially developed to cost little more than ordinary temporary jacketing materials.

New Low-Cost Jacketing Cuts Maintenance on Insulated Lines

AT LAST an aluminum jacket has been "engineered" especially to protect outdoor lines in refineries and chemical plants. It is the first "permanent-type" jacketing that offers both low initial cost and low application cost.

After two years of tests and major installations at 431 outdoor locations in refineries, chemical plants and power plants, the Childers Manufacturing Co. of Houston has rung up an impressive cost-cutting record with their Childers Aluminum Jacketing.

Secret behind this low cost is the thin aluminum sheet—.006" thick—which is the weather-protecting sheath of the jacketing. It is ribbed (as pictures show) for extra strength and to facilitate forming around the line. This aluminum has proved thick enough to resist weathering and usual abrasion, but costs much less than heavier aluminum sheets.

Easy application of this Childers Jacketing cuts labor bills drastically. It comes from the factory in easy-to-handle rolls that are four feet wide and either 100 feet or 200 feet long. It is light and flexible to handle as the men put it on the line. No roll forming required as with heavy, un-crimped material. It can be cut off and attached just the same as the old-fashioned tar-paper that was sometimes used for jacketing.

You can attach Childers Jacketing around your insulated lines by one of several easy methods. The use of aluminum strapping and seals is probably the best. Sheet metal screws or Minnesota Mining's No. 471 tape can also be used.

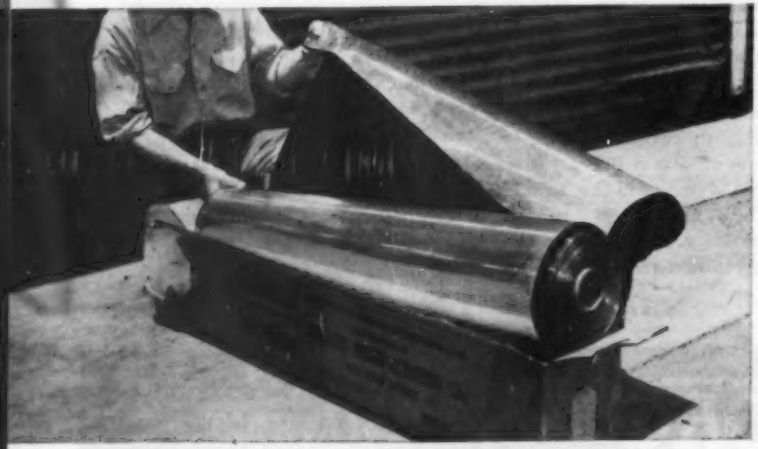
The Childers jacketing can be removed and re-used.

A moisture barrier is attached to the back of the jacketing to give positive protection for the aluminum when it is used with alkaline insulating materials.

No painting, no rust-proofing, little maintenance — that's the advantage of aluminum!

Hundreds of design engineers and maintenance engineers have agreed they save money for their firms and trouble for themselves by changing their jacketing specs to Childers 100%. That should make it worth your testing too—and a test roll costs only $40.00 for 400 sq. ft. (with moisture barrier attached—price for 800 sq. ft. without moisture barrier $62.00). That's a good investment in any plant.

FOR FULL INFORMATION write Childers Manufacturing Co., Dept. PR-5, 625 Yale St., Houston 7, Tex., for complete literature. Childers has engineering representatives in principal cities to work with you on specific problems.



This is how Childers Aluminum Jacketing is shipped in easy-to-handle rolls. It is quite flexible, yet stands up under severe weathering.

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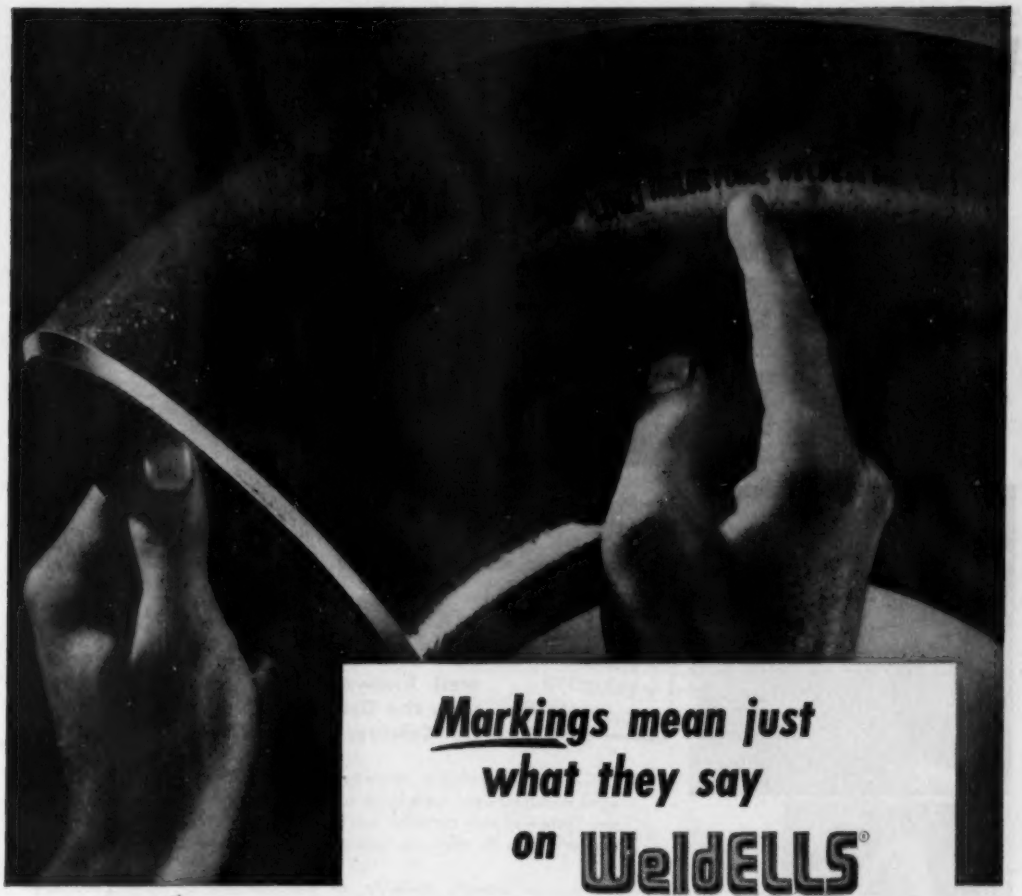

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It would be bad business for us to say this if thousands of users had not already said it for us and to us. "There are no bad ones" is nearly always the foremost reason given by practical men for insisting on WeldELLS.

Pick up any WeldELL and check it against the tabulation of its size, wall thickness, and other dimensions. It will be right on the head. And it will be right on the head in plus-value features, too—features that are combined in no other fittings.

Remember that the finest line of welding fittings is also the broadest line. Coupon brings your copy of useful data described below.

A VOLUME OF USEFUL DATA ON A SINGLE SHEET—Sizes, thicknesses and dimensions of all commonly used WeldELLS and Taylor Forged Steel Flanges ingeniously condensed on a heavy durable, letter-sized card. Indispensable for piping men. Coupon brings free copy.

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. . . handling bulk materials of every description at phenomenal savings

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. . . Celanese Corporation of America, well known for sound management, uses the Dempster-Dumpster System at its "Celriver", Rock Hill, S. C. yarn plant

Celanese Corporation of America is among the hundreds of well managed manufacturers, both large and small, who use the Dempster-Dumpster System of bulk materials handling . . . the system recognized across the nation for its efficiency and ability to reduce costs.

This system consists, basically, of one Dempster-Dumpster and any number of detachable Dempster-Dumpster Containers, which are spotted at convenient materials accumulation points inside and outside plants. With only one man, the driver, the Dempster-Dumpster picks up, hauls and dumps (or sets load down intact) one pre-loaded container after another. The capacities of the larger Dempster-Dumpster Containers are equal to and greater than regular dump truck bodies, and they are available in a wide variety of designs each suited to the type of materials handled—be they bulky, light or heavy . . . solids, liquids or dust . . . trash or rubbish. In some installations one Dempster-Dumpster handles as many as 100 or more containers—increasing man-power efficiency . . . reducing investment and maintenance costs . . . improving "housekeeping" methods . . . reducing fire hazards . . . and providing an easier, quicker, safer and more efficient manner of handling materials. It will pay you to investigate the Dempster-Dumpster System now! A product of Dempster Brothers, Inc.

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But even a visitor from the days of Egypt's Pharaohs would recognize two familiar facts — that strange modern "hieroglyphics" guide precise assembly of today's steel behemoths . . . and that Sun Ship workers are masters in their knowledge of the symbols and crafts of their trades. . . . The many modern industries served by Sun know these facts, too.

Illustration at top, reproduced from "The History of All Nations," shows ancient Egyptian shipbuilding as depicted on the tomb of Ti, at Sakkara. In contrast is the 55' regenerator being built by Sun.

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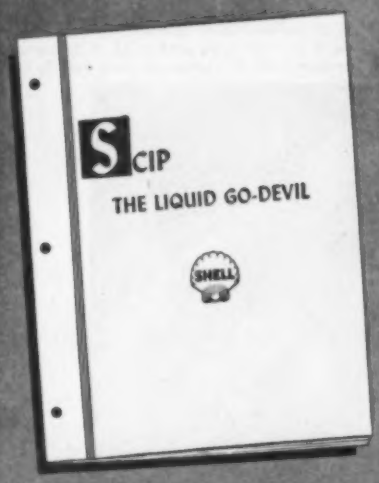

This booklet tells all about SCIP. Mail coupon for your copy.

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- **HAS NO EFFECT ON PIPED PRODUCTS**
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Products amounting to *many millions of barrel-miles per day* are now transported at full capacity in pipe lines kept free from scale by SCIP. The dollars-and-cents savings pay for a SCIP installation many times over in the course of a year's operation. If your lines are not delivering full capacity because of corrosion, be sure to fill out and mail the coupon for Shell's booklet, "SCIP, The Liquid Go-Devil."

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Please send me a copy of "Scip—The Liquid Go-Devil."

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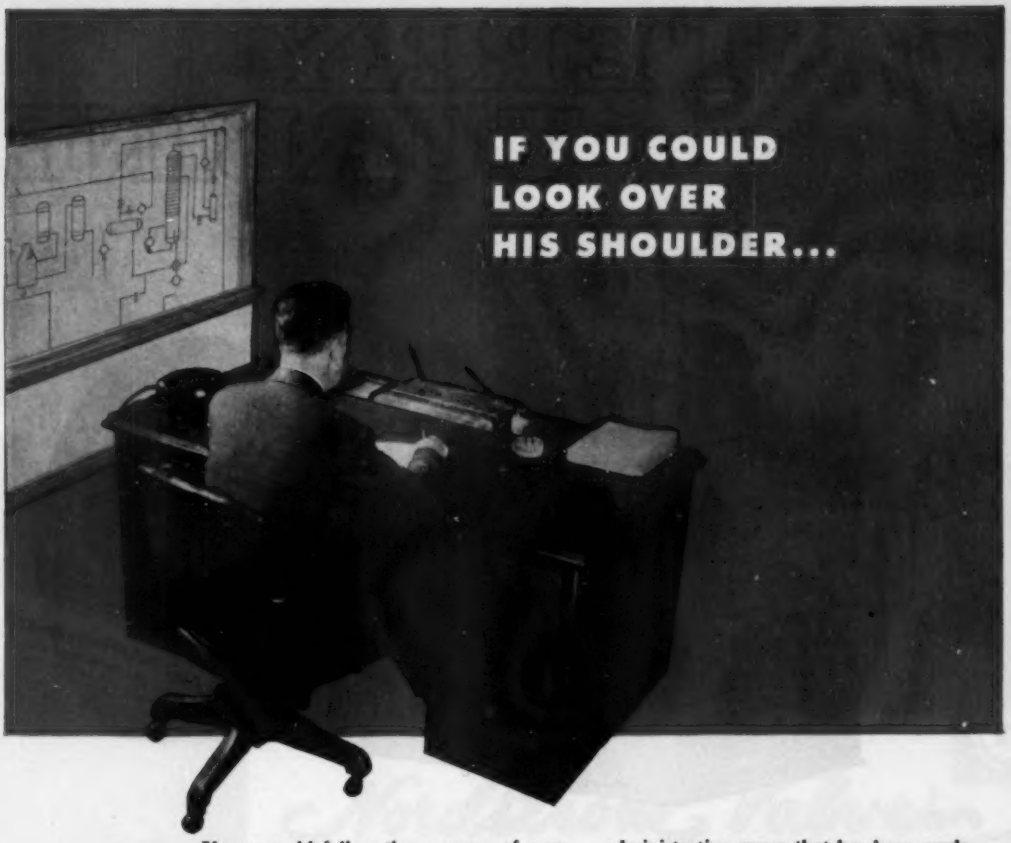
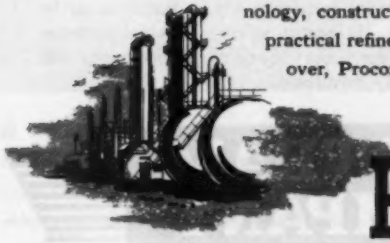


If you could follow the progress of a refinery construction job as it is handled by the Procon organization . . . watch the work progress from blueprint to finished plant, you would understand why Procon service assures you *maximum value for every dollar invested.*

Here is a balanced organization of highly skilled personnel, thoroughly experienced in engineering, petroleum refining technology, construction know-how and practical refinery operation. Moreover, Procon is directed by an administrative group that has been working together in refinery processing installation and operation for many years. Thus every job receives the over-all benefit of strategic planning and resourceful thinking.

Procon Incorporated offers a complete process construction service in the petroleum refining and petro-chemical industry. The opportunity is here to acquire the services of a capable organization, unusually well-grounded in practical experience and technical knowledge.



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PROCESS CONSTRUCTION

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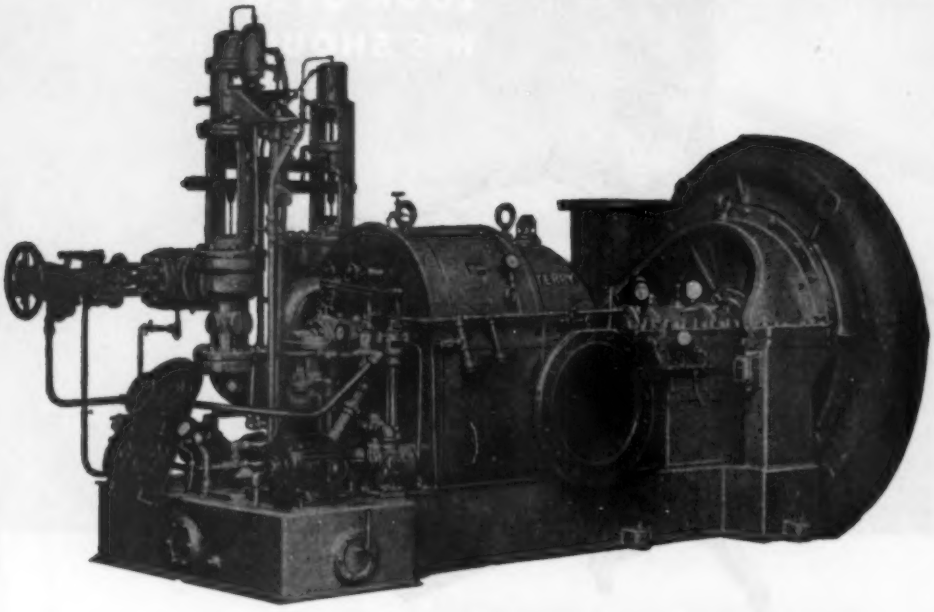
The TERRY TURBINE



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FOR OPERATION UNDER ALL THESE CONDITIONS:

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2. Straight, low-pressure, condensing — putting to work excess low-pressure steam.
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. . . and the speed under any of these conditions can be varied from 2800 to 4750 rpm.

This is but one example of many unusual combinations developed by Terry to meet out-of-the-ordinary requirements in turbines up to 2000 hp. Information on a special-purpose turbine for your specific requirements will be gladly furnished.

T1177

THE TERRY STEAM TURBINE COMPANY
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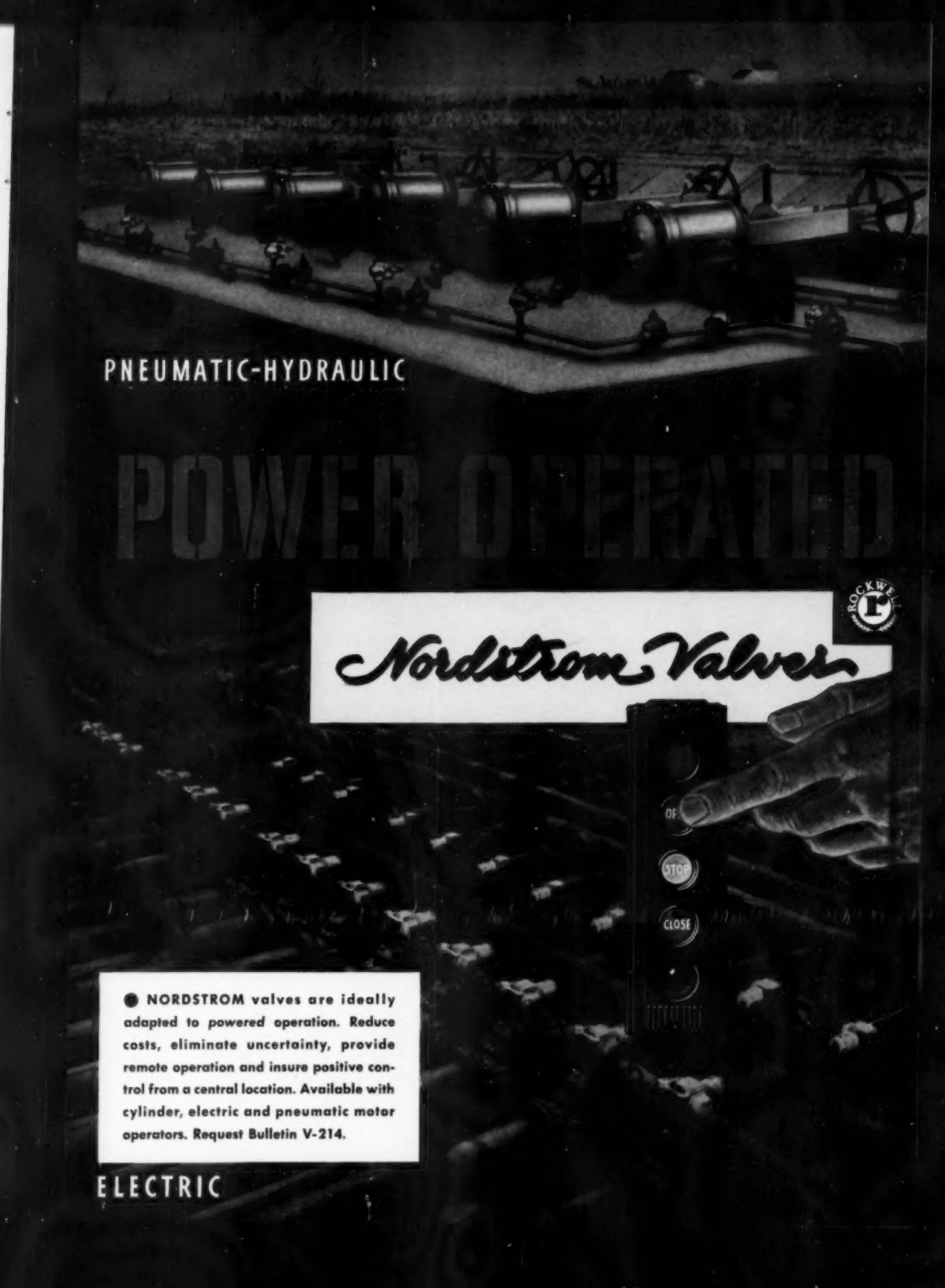

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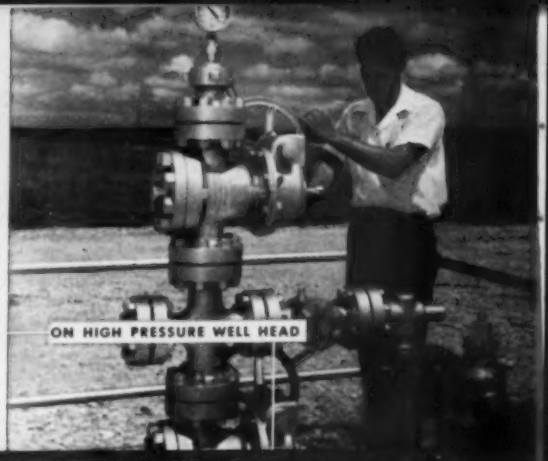

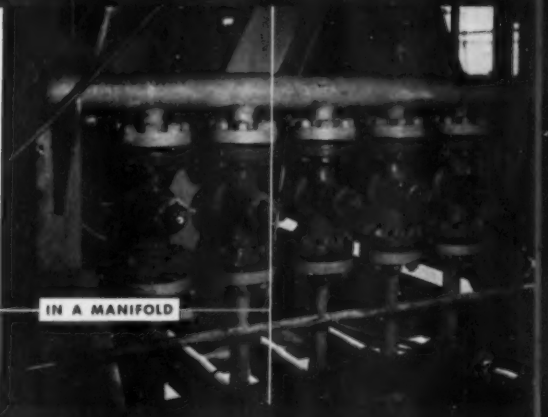

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Kaylo Heat Insulation is easy to handle and apply—in all sizes, shapes and thicknesses—because of its high structural strength and light weight. This remarkable combination of high strength and light weight makes possible speedier application. It provides for units of greater size which permit larger surfaces to be covered faster. With these combined features, Kaylo Heat Insulation gives exceptional ease of handling—offers substantial savings in application costs.

Kaylo Heat Insulation is a hydrous calcium silicate (not glass) with a wide effective temperature range—up to 1200°F. It is inorganic and insoluble in water, incombustible and retains its dimensional stability in long service under severe conditions.

KAYLO PIPE INSULATION is made to Simplified Dimensional Standards of thicknesses and diameters. Coverings are sectional for tube and pipe sizes ¼" to 12"; tri-segmental up to 23"; quad-segmental up to 41"; K-segmental (18" wide segments) up to 72" in diameter.

KAYLO HEAT INSULATING BLOCK is made in all standard sizes and thicknesses from 1" to 6" for flat surfaces and for vessels larger than 60' in diameter; curved block 18" wide for smaller vessels.

SEE OUR CATALOG IN THE REFINERY CATALOG

For complete details on Kaylo Heat Insulation, write Dept. N-167, Owens-Illinois Glass Company, Kaylo Division, Toledo 1, Ohio.

KAYLO® ...first in calcium silicate

...pioneered by OWENS-ILLINOIS Glass Company

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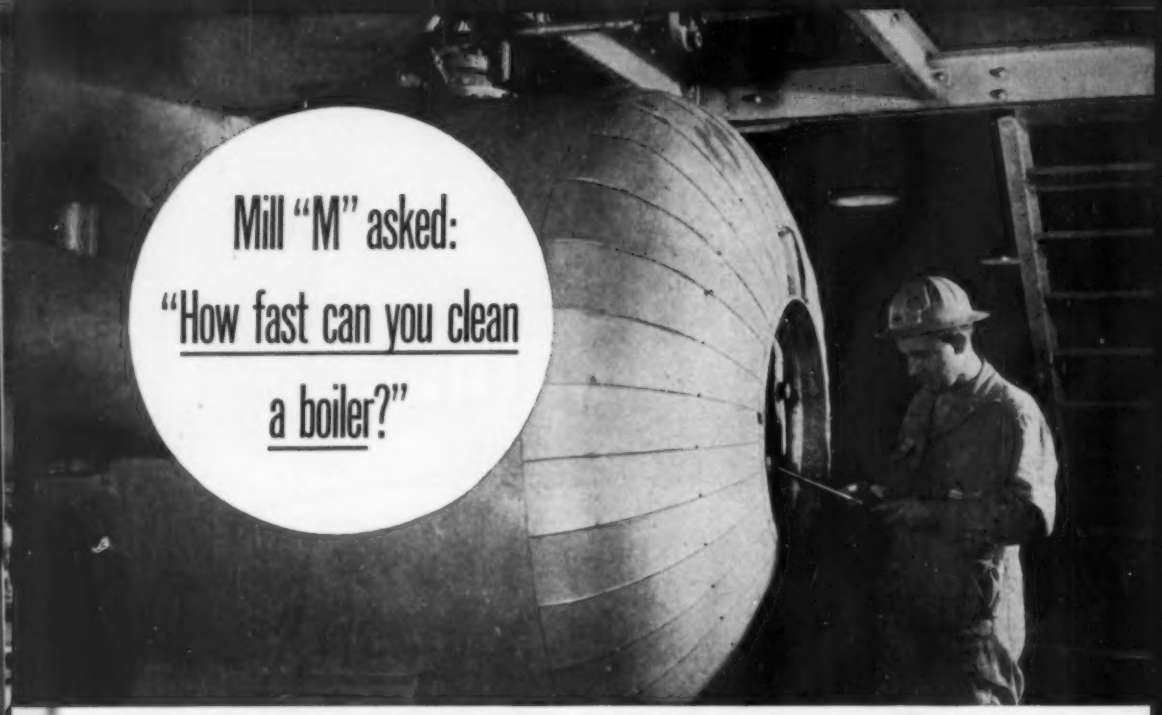

Dowell Service cleaned the internal surfaces in 10 hours!

This was the case of a boiler generating 350,000 pounds of steam per hour with an operating pressure of 1250 p.s.i. In ten hours Dowell Service removed an estimated 1,000 lbs. of deposits which were causing tube failures. The boiler was back on the line the next day.

What is Dowell Service? It is simply the application of chemistry to the problem of removing deposits from heat exchangers, water lines and all kinds of process equipment. Dowell engineers fill the equipment with liquid solvents which reach wherever steam and water flow and are designed to dissolve and disintegrate the deposits efficiently and quickly. Dismantling is not necessary.

Somewhere in your plant there is a job that can be done *faster, better, more economically* by Dowell Service. Let an experienced Dowell Service Engineer help you with your maintenance planning. No obligation, of course.

Other recent Dowell jobs:

Entire Piping Systems of two college dormitories cleaned of scale.

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Three Formaldehyde Contact Towers and Reboilers cleaned and restored to designed operating efficiency.

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Six Black Liquor Evaporators cleaned for paper company. Deposits removed from vapor and liquor sides in one operation.

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DOWELL

A SERVICE ORGANIZATION

PETROLEUM REFINER

The LOOK BOX

INSTEAD of trying to knock integration out of business, it seems that government could stand to borrow a little of it from the oil industry, to put the left and right hands into harmony, and build up a working relationship between industrial policy and national interest.

Integration Is National Asset

This is a part of the challenge to recognize industrial integration as a national asset which was issued last month by T. S. Peterson, president of Standard Oil Company of California.

In discussing the seeming attempt of government to tear leaders of industry limb from limb in an effort to "roll back the calendar to Stanley Steamer days," Mr. Peterson very truthfully recalled that industry of that undeveloped era could hardly be expected to cope with today's national and international responsibilities.

"The government has not tried to divorce the fisherman from his pushcart," said Mr. Peterson, "nor the editor from the reporters, printers or circulation people who cooperate to get the papers into your hands. However, it has undertaken a determined and methodical campaign to break up the large, integrated industrial concerns. And the public, whose money, convenience, and national welfare are deeply involved, is entitled to ask why."

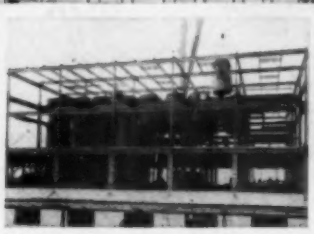
The oil business which has been placed right in the middle of the target area by virtue of government Antitrust Division suits filed against seven large western oil companies, has used integration as a method of assured supply, constantly improving quality, and fair prices which benefit the public generally and make the industry's huge military supply program possible, Mr. Peterson pointed out. He admitted that if the oil business is doing wrong by the public, it should be stopped, but otherwise, the public had better see to it that the industry is not thrown out of gear and utterly out of commission.

Recalling the early hectic days of the oil industry, a period of wildly fluctuating prices and supply, he pointed to integrated operation as the system which later brought about a competitive and progressive oil industry.

Peterson reasoning:

> "I am perfectly willing to admit a prejudice in favor of the present American manner of doing things—the traditional, free-wheeling free enterprise system. But I believ it's a bias with a foundation in common sense. . . . If the meddlers had their wish and the big, integrated companies were broken up the way would be wide open for the very monopoly that the antitrust division is disposed to see in connection with the present setup.
>
> "To prevent the oil industry from following a normal, healthy expansion along integrated lines—the producing-refining-distributing-marketing right of way—would certainly invite the less scrupulous outfit to expand in the only other way possible. That would be laterally, throughout the single field to which it was confined. If it were a producer it would buy more wells; if a marketer, it would buy up more and more service stations.
>
> "The government could step in, of course, and smash the horizontal monopoly—if necessary it could take over the industry lock, stock, and barrel. Indeed, it seems increasingly that some people in government may have in mind to bring about just that condition if they can, and that would result in the most suffocating monopoly of all—a government monopoly. There are plenty of philosophical reasons for resisting this effort—our instinctive distrust of collectivism, socialism, and the like—but there are some very practical reasons, too, as I hope I have made clear.
>
> "If we can assume that the government as sole proprietor of the nation's oil business would have no higher regard for the principles of efficient and economical operation that it is displaying in this campaign to disintegrate the industry and send it back to the Stanley Steamer days, then Heaven help the consumer. For the prices would certainly

Top-of-Page Photo—Lights outline forms of a cat cracker and auxiliary units at the East Chicago, Ind., plant of Cities Service Company. Capacity of this refinery is 35,000 barrels daily. (Photo courtesy of "Service," Cities Service magazine.)



Fabricated by an equipment builder using the Lukenomics principle.

Thoughts on the Crisis

. . . from a Storage Tank

Is "nervous" efficiency threatening your defense production plans with a mechanical ulcer?

Perhaps a new imaginative *approach* to your problem would help. The ideas of a creative equipment builder, for example.

For we know some outfits who think beyond specifications. Builders who design *inventively*, building backbone into your plant, muscle into your potential.

And builders like this apply Lukenomics—for the extra fuel of designer and engineer, as well as our own knowledge of materials, their production and use.

Get the names of some of these builders. Write today, stating your problem. Manager, Marketing Service, Lukens Steel Company, 404 Lukens Building, Coatesville, Pennsylvania.

Promote steel production generally—speed sale of your scrap.

The Cities Service Oil Company at Cicero, Illinois, needed process equipment for fatty materials to be blended into greases. The problem: How to achieve peak product purity in the presence of materials which threatened discoloration. Coordination among designer, engineer, and equipment builder delivered an economical answer: Storage tanks fabricated of Lukens Stainless-Clad Steel. Results include low initial equipment cost . . . a solution to discoloration problems . . . new *purity* assurance . . . provision for smooth production of a high quality product. And in addition, by use of clad steel, the builder effected an important saving in a critical metal. This is *Lukenomics* at work.

OVER 140 YEARS' EXPERIENCE AS THE WORLD'S LEADING PRODUCER OF SPECIALTY STEEL PRODUCTS

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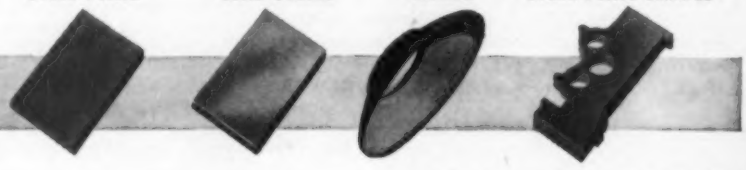

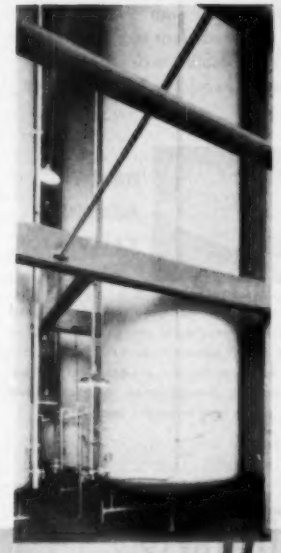

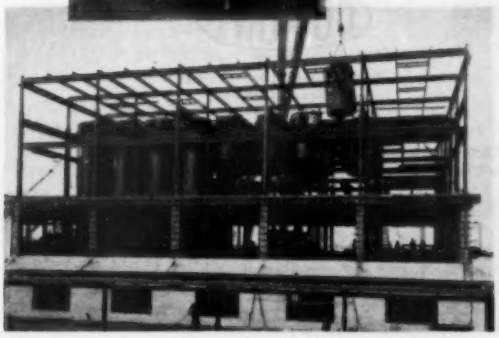

Stainless by LUKENS . . . Fabrication by GRAVER

Serving as the supply center for the Great Lakes and Midwest distribution areas, the new Cities Service compound and blending plant, near Chicago, will add a grease compounding section to its facilities. Important in this expanded operation are four large stainless clad storage tanks . . . fabricated and erected by Graver.

Altogether, there are 127 Graver tanks at this huge plant which now blends solvent-refined base stocks into super-quality "heart cut" motor oil. Supplied by barge from the Cit-Con lube oil plant at Lake Charles, La., the Cicero plant has a capacity of 50,000 gallons per day.

The fabrication of 93 shop-erected and 34 field-erected tanks indicates the scope of Graver service in furnishing tanks and vessels in any quantity . . . any size and shape . . . carbon or special steels, solid stainless or stainless clad.

GRAVER TANK & MFG. CO., INC.
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To help meet the growing demand for aviation gasolines ...

A COMPLETE LINE OF DU PONT ADDITIVES

The demand for aviation gasolines is constantly rising. To help you maintain quality standards easily and economically, Du Pont offers a complete line of gasoline additives. These are especially adapted for use in aviation fuels and are compatible with each other in every way.

In connection with these additives the services of the Petroleum Chemicals Division Field Laboratories are available to you. The laboratories will evaluate your gasoline and recommend the most efficient use of any of our products. For full details, write the nearest Du Pont Petroleum Chemicals District Office listed below.

TETRAETHYL LEAD COMPOUND—*Aviation Mix*

Du Pont Tetraethyl Lead Compound—Aviation Mix is backed by 25 years of manufacturing experience and supported by extensive research. It is supplied to you with complete, helpful services applying to blending operations and safety.

GASOLINE ANTIOXIDANT No. 22

To assure maximum stability of your aviation gasolines we offer Du Pont Antioxidant No. 22. This is a commercial grade of N,N' di-secondary butyl-para-phenylene-diamine.

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For aviation gasolines, many refiners prefer Du Pont Oil Blue A to meet color specifications. This dye can be combined with Du Pont Oil Yellow N to obtain green, and with Du Pont Oil Red if purple is required.

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HANDY BLENDING CALCULATOR

This Du Pont Blending Calculator was specially designed to help expedite the blending of your aviation gasoline with Tetraethyl Lead Compound—Aviation Mix. A real time-saver, it is yours for the asking! Your Du Pont Petroleum Chemicals representative or the nearest District Office will be glad to supply you.

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go up and the quality down, and as for the service, you know how much of that you'd get.

"I don't know that this is what the government has in mind, but the current government policy can't to open the door to one kind of monopoly or the other. And if it's the American business system we're interested in preserving, we shall be better off to preserve the already tested system that affords its own checks and balances—its own built-in guarantees against all forms of monopoly.

"Another thing I am afraid would happen under the government's disintegration scheme—and the most ominous, certainly in terms of the immediate picture—is that a crippling handicap would be laid upon the nation's military preparedness program.

"When the government needed unprecedented production it turned to the larger, integrated companies and said, 'This is your job.' When special lubricants, special fuels, higher octane gasolines for the military were needed the government turned again to the larger companies and said, 'Let's have them.'

"So they got the quantity and the quality . . . because the integrated companies were ready for this kind of assignment. These were the companies that had the research facilities, the refineries, the networks of pipe lines, the marine fleets, the streamlined production techniques to do the wartime job. They knew distribution on a vast scale. They were the companies that had developed the internal teamwork, if you will, to take over the massive task.

"The integrated companies are the mass producers, the assembly-line organizations of the oil industry. Like their counterparts in the steel, automobile, electrical, and chemical industries they have developed over the years the methods that enable them to serve the consumer the best product at the least cost, and the same thing holds true whether the consumer is the proprietor of a station wagon or a 40-ton tank.

"The continuance of this kind of ability is also the very basis of the job that nation has got to do in rebuilding the free world."

Mr. Peterson's vigorous statement is no stronger than it should be. And it comes at a timely moment. As he points out, "this is the mid-20th century and we've a tragic situation on our hands." Actually the government has little reason to go forward with its meddling pursuit of industrial disintegration and the hour it has chosen is, unfortunately for the people of the U. S. and perhaps the entire world, most inappropriate.

"The key to the strength of the American oil industry is the driving force of competition. This strength must be preserved if the United States is to remain a power for peace. Even with national planning and restrictions, the nation must continue to rely on private management, and although close and full cooperation with governmental agencies is necessary in times of emergency, nothing should be done that will impair the incentive for competition in normal times."

. . . FRANK M. PORTER, president,
American Petroleum Institute

Daring Economic Adventure

ONE of the most "daring" enterprises that any country has ever undertaken, according to Chester H. Lang, General Electric Company vice president, is the present United States economic program to pile billions in defense output on top of a "whopping" civilian production. In his estimation, the present program is designed to bring security and lasting strength, unless we lose our balance or shirk our responsibilities and pave the way for galloping inflation and chaos.

It follows therefore that every American must prepare for a first-team role in the greatest production drive in world history if the U. S. is to retain its peacetime health while building its global defenses. New explosions of peak demand and productivity will not be limited to the area of military goods, but will occur in every phase of the nation's economy during the next five years.

Mr. Lang has predicted that the first demand will be for producers' equipment, and will reach its peak this year. This will mark the first phase of the mobilization plan, that of increased over-all productive capacity. This production spurt will continue until 1953, at which time he believes the index for producers' equipment will drop below the levels of the past three years.

His second series of production peaks concern military durables, tanks, planes, etc., and this peak too, will reach its high point in 1953, and will in turn be succeeded by a spurt in consumer durables such as automobiles and major electrical appliances, which he estimates will reach its peak year in 1954. In Lang's opinion, these trends are not inevitable, could indeed be altered by any new factors, especially all-out war.

The entire mobilization program could easily be scuttled by a "whole new race of super-boondoggers" which is expected to emerge in the coming years of crisis. Mr. Lang asserts that one of the most important jobs ahead for the American businessman is the combatting of efforts to force a "slowdown" in mobilization plans.

"The $265 billion civilian economy of American industry undergirds the entire military structure," said Lang. "If businessmen fail to keep civilian economy running at peak, the program will fall apart."

"Even if military demands continue to increase, the petroleum industry if left reasonably free and solvent, and if permitted to get the necessary steel and other materials to maintain its exploration and drilling program, will equal and surpass its records during World Wars I and II. In both of these four-year struggles, no military action was deferred or curtailed for lack of petroleum products and no essential civilian needs went unfilled."

. . . L. S. WESCOAT, president,
The Pure Oil Company

Announcing BI-ACT* Single-Adjustment of

CONTROLLER with Proportional & Reset

An inexpensive force-balance controller with proportional and automatic reset adjusted by a single knob. Particularly suited for flow applications. A logical addition to the TRANSET* Control System.

BI-ACT is TRI-ACT's* little brother. The inexpensive BI-ACT Controller has *two* control responses, proportional and automatic reset, with both adjusted by *one* knob. It is the ideal controller for dependable, accurate performance on locally mounted flow and similar control applications where it is felt that the quality of control obtainable with the three responses of the TRI-ACT Controller is not essential.

TAYLOR'S NEW BI-ACT CONTROLLER GIVES YOU:

1. Single-Adjustment of Proportional and Reset.

2. Simple stability "tune in".

3. Low cost.

Taylor's TRANSET Control System, with its three component units, is the new concept in pneumatic control that everybody is talking about. The three units, TRANSAIRE*, TRI-ACT and TRANSET, are designed to work together as a team to take advantage of each other's superior performance on all applications. Now Taylor has added the inexpensive BI-ACT Controller to extend the scope of the 3-part Transet Control System.

Write for Bulletin 98070

Taylor Instrument Companies,
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Instruments for indicating, recording and controlling temperature, pressure, humidity, flow, liquid level, load, speed, and density.

*Trade-Mark

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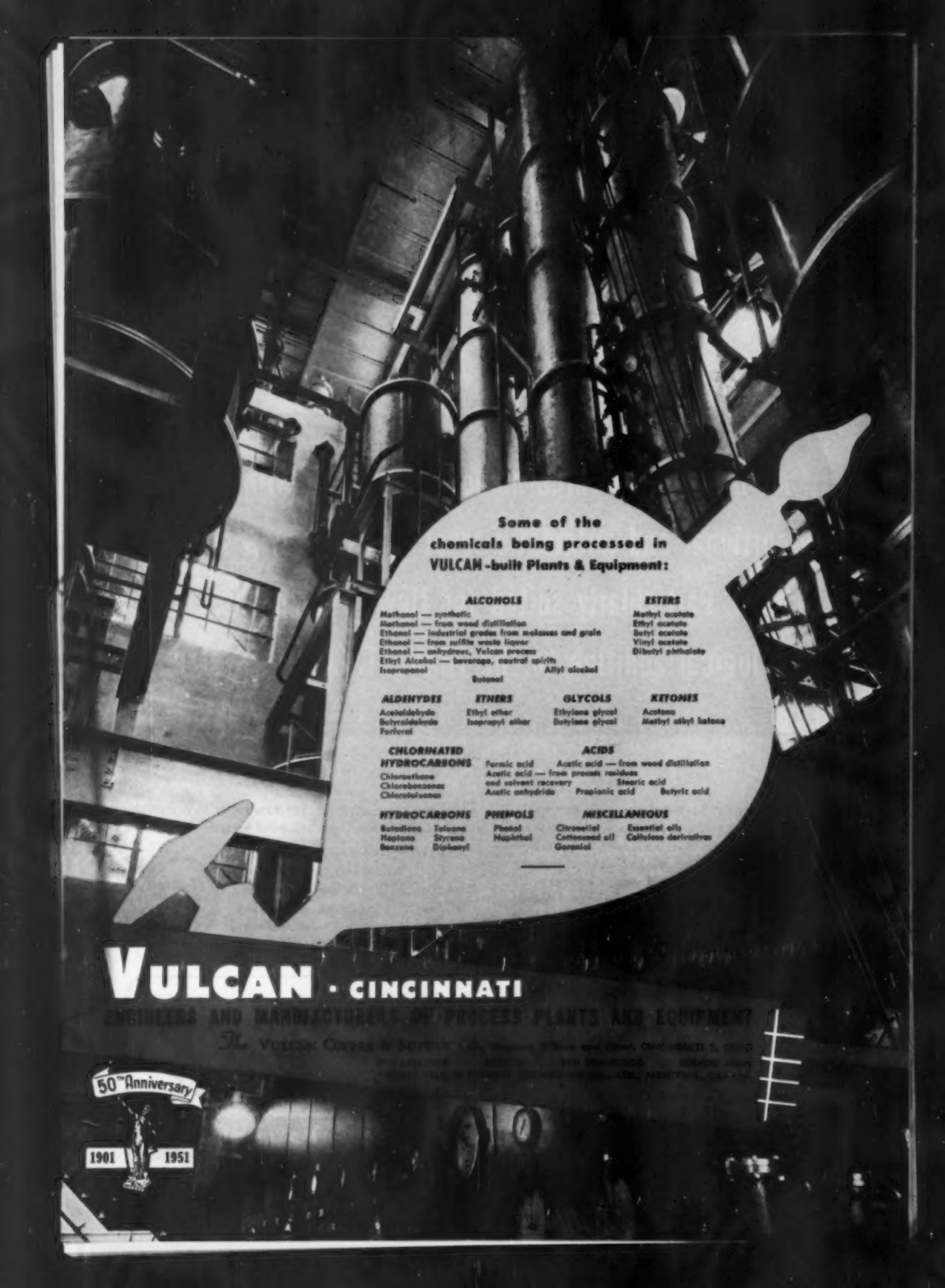
Some of the
chemicals being processed in
VULCAN-built Plants & Equipment:
ALCOHOLS
Methanol — synthetic
Methanol — from wood distillation
Ethanol — industrial grades from molasses and grain
Ethanol — from sulfite waste liquor
Ethanol — anhydrous, Vulcan process
Ethyl Alcohol — beverage, neutral spirits
Isopropanol
Allyl alcohol
Butanol
ESTERS
Methyl acetate
Ethyl acetate
Butyl acetate
Vinyl acetate
Dibutyl phthalate
ALDEHYDES
Acetaldehyde
Butyraldehyde
Furfural
ETHERS
Ethyl ether
Isopropyl ether
GLYCOLS
Ethylene glycol
Butylene glycol
KETONES
Acetone
Methyl ethyl ketone
CHLORINATED HYDROCARBONS
Chloroethane
Chlorobenzenes
Chlorotoluenes
ACIDS
Formic acid
Acetic acid — from wood distillation
Acetic acid — from process residues and solvent recovery
Stearic acid
Acetic anhydride
Propionic acid
Butyric acid
HYDROCARBONS
Butadiene
Heptane
Benzene
Toluene
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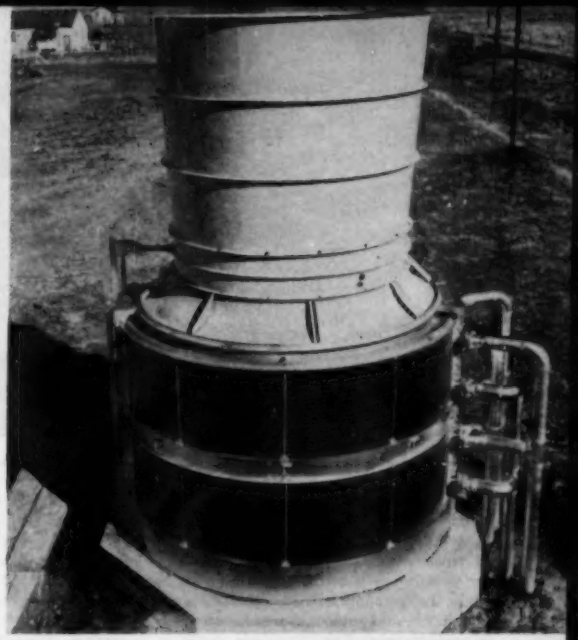


Figure 1. Air-Cooled Heat Exchanger used in areas where water is costly or undependable. All photos courtesy J. F. Pritchard & Company.

Water Supply Big Factor in U. S. Industrial Strength

RAYMOND C. KELLEY

Manager Equipment Division, J. F. Pritchard & Company, Kansas City, Mo.

IRRIGATION of farms, processing of food stuffs, operation of air conditioning and refrigeration equipment, production of pharmaceuticals, medicines, petroleum fuels and chemicals, power generation and, consequently, the over-all industrial facility of the nation requires abundant, inexpensive, chemically clean, relatively cold water. Recently much has been written concerning critical local shortages in water supply. The national press has carried news items describing the near-disastrous shortage in metropolitan New York City resulting from decreased rainfall in the area. In recent years the effect of gradual declining underground water tables has focused attention on major industrial centers including Dayton, Toledo, Louisville, Peoria and Chicago. In vast areas of the south and west, from the earliest days, water has been regarded as a limiting factor in industrial development.

An effort to confine our present discussion to the problem of industrial water conservation in the midwestern United States, directing particular attention to the involvement of the power industry, accentuates the complexity of the basic problem. Statistical data are rapidly being accumulated in usable form. Sources of collateral data are being tapped for pertinent facts. Although correlation may be difficult, concerted effort by all concerned will shorten the time required to effect satisfactory solutions. The power industry can well afford to take the lead, demonstrating by efficient, well engineered applications that improved technology can avoid dissipation of a basic natural resource.

It is not appropriate that engineers quietly accept unqualified generalities such as "large chunks of our country are running out of water" or "in several areas water levels have dropped 55 feet in six years" or "the Louisville watertable is down 40 feet in ten years." We must develop accurate data coupled with intelligent analysis and specific recommendation. Federal agencies, state commissions and local groups have become aware of the importance of industrial plant conservation measures. The active attack on the problem has already begun. Aggressive pursuit must follow. It is not good management to waste water when invocation of water conservation methods can reduce the slope of the operating cost curve. Growth in demand load reflects directly the industrial growth and population increase of a geographical area. Without effective procedures for water conservation, the natural laws of diminishing returns are invoked. With but one common source of supply, the necessity of mutual approach to the problem is self-evident.

TO SUCCEED in our efforts toward international leadership in world peace by virtue of strength, we have a major task yet to complete. Although many elements of our industrial, political and social economy have been well studied and substantially planned, the primary natural resource of water is yet to be adequately measured for availability, thoroughly studied for distribution and comprehensively protected by intelligent utilization. Our ultimate industrial strength may well be dependent upon the availability of water.

Original presentation was before the annual Midwest Power Conference, Illinois Institute of Technology, in April. Mr. Kelly is president of the Cooling Tower Institute.

Omitting statistics from new plants built during the period of 1939 to 1949, it is apparent that the use of water by established basic industries in the midwestern area has increased more than 40 percent in the past decade. Of the total water consumption in the average large industrial plant 53 percent is used for cooling, 31 percent used in process, 8 percent in boiler feed water, 5 percent for sanitary purposes and approximately 3 percent for miscellaneous demand. In the major industries, **increases** in total water requirements are estimated for the ten-year period ending in 1949 as follows:

Aircraft and auto	82%
Medical supplies	73%
Petroleum	58%
Machinery & tools	52%
Electric power generation	51%
Chemical and drugs	45%
Iron & steel	45%
Foods	38%

The establishment of new midwestern industry within this ten-year period accounts for an additional 12 percent demand on the water resources of the area.

Although the total power-generating facility of the country is divided into four major categories for statistical analysis, we must keep in mind that those plants dependent upon surface water or underground water constitute 96 percent of the total installed capacity. Our present production of energy comes 50 percent from coal, 32 percent from oil, 14 percent from natural gas and a round number 4 percent in hydro developments. In the average steam turbine plant, 92 percent of the water requirement is for condenser cooling.

Figure 2. Typical Induced-Draft Cooling Tower with Pumping Station in foreground at Large Mid-western Refinery.

With the power industry being encouraged to increase its gross generating capacity at a rate of 5 million kilowatts per year for each of the next ten years, a new water supply of 10 million gallons per minute may be required. Restrictions on the use of surface water, resulting from public welfare activity in the development of fish and game preserves, stream pollution abatement and public health programs, dictates this increased water requirement be developed, in the majority, from underground sources. Yet available data indicates a current withdrawal exceeding natural replenishment in most industrial areas.

Our present average gross consumption of water is approaching 800 gallons per day per capita. If only the power industry water requirement be considered or if only, by itself, the other industrial water load be considered, we might not be so actively concerned. However, when confronted with a constantly increasing population, with its domestic demand, we face, at the same time, the problem of developing an **additional** 100 gpm. per capita supply within the area in the next ten years. Although equating this total demand against our average 30 inches of rainfall per year over the continental land mass shows that we have developed facilities to utilize only 2 percent of the total precipitation, we find the cost of water conserving equipment to be generally less than the cost of developing new sources of raw water. An extreme case at point is the new Key West, Fla., 5000-kw. steam-turbine unit for which fresh water supply is pumped 150 miles through a 14-inch diameter pipe. A cooling tower is here definitely indicated.

On both coasts and across the northern third of the mid-continent area a gradual decrease in measured rainfall is recorded over the last 50 years. Wisconsin shows a decrease of 3.48 inches per year, New Jersey a decrease of 3.81 inches per year and Oregon a decrease of 3.81 inches per year. This is not yet established as a positive trend but is deserving of critical analysis before contemplated reservoir replenishment is accepted for power production within any one locality.

Statistics from the December, 1950, publication of the Economic Policy Division of the National Association of Manufacturers covering basic industrial requirements on water use per unit of product are excerpted as Table 1 shows:

TABLE 1

COMMODITY	Unit	Avg. Water Requirement, U.S. Gallons
Milk	1 gallon	5
Beer	1 gallon	15
Standard Gasoline	1 barrel	10
Refined Petroleum	1 barrel	420
Aviation Gasoline	1 barrel	1,000
Synthetic Gasoline	1 barrel	15,834
Corn on the Cob	1 ton	1,000
Corn Syrup	1 barrel	3,180
Soap	1 ton	4,493
Ice	1 ton	5,000
Steel	1 ton	65,000

By comparison the requirement of one gallon of circulating condenser cooling water per kilowatt of energy delivered to the lines of a steam turbine generator unit is a modest demand. As production requirements increase to meet the demand of augmented population, proportionate increase in water requirement is inevitable. Recognizing the tenet of public domain, with protective rights endowed upon our neighbor under our constitution, it behooves the industrial user to minimize wasteful consumption of water.

The cooling tower industry is dedicated to improvement in the technology, design and performance of water conservation equipment. On this foundation, the formation of the Cooling Tower Institute was recently completed. The Institute hopes to share with industry responsibility of encouraging action on those steps necessary to avoid experiencing, as did the Union of South Africa, "an industrial slowdown because of an acute shortage of the most valuable mineral of all—water." We are not committed to the support of any particular style or type of cooling device. We are searching constantly for more efficient equipment suitable to general industrial cooling requirements and to our temperate climate. Our relatively high summer-time dry bulb temperatures virtually preclude the use of natural draft type hyperbolic shaped chimney towers extensively applied in power plant duty on the European continent. We do not have the steam wells recently developed in Italy where natural steam supplants the boiler in generating turbine steam which in turn goes through the standard expanding and condensing cycles. Even with such a natural steam source, cooling water for condensing is an essential requirement for the economical production of energy.

It is not enough to expend the waste disposal facilities of a community although excellent work in this separate field has been completed by the Industrial Wastes Conference at Purdue University, the Industrial Wastes Conference at Texas A. & M. College, the New England Industrial Wastes Conference and those several groups sponsored by the American Chemical Society, the American Institute of Chemical Engineers and the American Petroleum Institute.

In the gradual development of the cooling tower and the air cooled heat exchanger, conservation of water has been the primary objective. Although in certain localities rivers, lakes and ponds can supply small power plants with sufficient cooling water during the majority of the year, the forward looking engineer plans his plant around the use of spray ponds, evaporative coolers, atmospheric deck-type cooling towers, forced draft cooling towers or the more popular mechanical design known as the induced draft cooling tower. Each device utilizes the physical phenomena of latent heat in its function. For each pound of water evaporated within the equipment, approximately 1000 Btu. of waste heat is ultimately dissipated into the atmosphere. In power plant duty, efficient cooling of the condenser water results from the circulation of 8 to 10 gallons for each 1000 Btus. heat dissipation. Typical water flow characteristics of three steam power plants currently under construction are shown in Table 2.

TABLE 2

Basic Capacity (Corrected to P.F. = 1) Kilowatts	Steam Condensing #/Hr.	Inlet Water Temp.	Condenser Water Circulation
25,000	175,500	84°	25,000 gpm.
20,000	150,150	80°	20,550 gpm.
5,000	49,000	82°	6,950 gpm.

For the plant operator to obtain pre-

BRIDGEPORT BRASS COMPANY

CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

"Bridgeport" MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Preventive Maintenance Helps To Attain High Production

Corrosion and fouling are two of the greatest offenders in petroleum refining. Corrosion shortens the life of the equipment while fouling builds up coatings of "gunk" and scale which reduce the heat-transfer rate and often accelerate corrosion.

The established practice of operating equipment beyond its rated capacity, in order to obtain maximum production levels, may have a very destructive effect on service life of equipment.

Importance of Keeping Heat Exchangers Clean

Recognizing that corrosion and fouling are major menaces to production and profit, most of the petroleum refineries keep staffs of trained people to carry on a program of periodic inspection and preventive maintenance.

Careful records are kept of the performance and life of each piece of equipment, the nature and volume of the product; the cooling or heating medium; the composition of the tubes; the character of the corrosion and its effect on the life of the tubing. These records, built up over a period of years, indicate the expected tube life. Consequently, replacements can be made before failures actually occur.

Periodic inspections are made on each piece of equipment. The ones giving the greatest trouble are inspected more frequently. New equipment is thoroughly overhauled and inspected within a few months or at most within a year after it is put into operation to learn how it is standing up and to estimate its probable service life.

Corrosion Prevention from the Product Side

Refined petroleum products in themselves are not corrosive. Sour crudes, however, carry corrosive elements such as sulphur compounds, salts (mainly sodium and magnesium chlorides), and ammonia compounds. Salts are especially troublesome since they precipitate out and form a hard crust on the tube wall and are exceptionally corrosive to stainless steel. The establishment of a desalting process for treating all crude before it enters the equipment has reduced or eliminated this problem.

Where it is not practical to remove the sulphur, alloys and metals that resist sulphur corrosion are used. Arsenical Admiralty and arsenical Muntz are satisfactory when the concentration of other corrosive elements is not excessive. Sometimes Duplex Tubing with aluminum to the product side and arsenical Admiralty to the water side, may solve this problem.

Accumulation of trash on inlet ends of tubes in salt water cooled surface condenser.

For excessive ammonia, Duplex Tubing with steel to the product side and arsenical Admiralty or some other copper-base alloy to the water side, is recommended.

Fouling Accelerates Corrosion

The clogging of tubes and equipment with marine growth, which becomes especially troublesome in warm weather when circulating sea water is used, is retarded by chlorination. This is done periodically during each shift and varies with the season.

Severe storms which disturb the water and bring in silt and eel grass are surprisingly costly. Eventually the silt is removed by the force of cleaner water and by flushing, but eel grass, which may pass through the strainer plates and one or two passes of a large surface condenser, may mat on the tube sheet leading to the third or fourth pass and reduce circulation to a dangerously low level. Here only a complete shutdown and mechanical removal of the grass are called for.

The application of heat to most crudes causes the precipitation of carbonaceous compounds. These cling tenaciously to all metal surfaces and quickly build up heat insulating layers which reduce the heat transfer properties of the tube wall.

Overheating the tubes may lead to accelerated corrosion and, in cases where the circulating water is blocked off, the tubing may also be distorted by thermal stresses.

In order to determine the cleaning cycle, which is most economical, tests are made periodically to ascertain heat and capacity losses. This is plotted against the cost of cleaning and the downtime capacity loss. When the composite curve of these values begins to flatten out, the cleaning cycle is determined and scheduled.

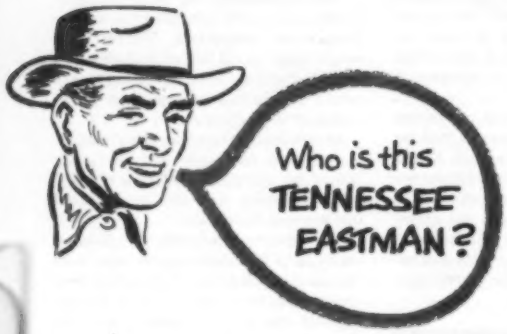
Where the deposit is hard and cannot be easily removed by solvents or acids, the condenser or heat exchanger tube bundle is cleaned inside and outside by high pressure water containing an abrasive such as sharp sand. Certain types of deposits are very effectively removed by steam cleaning or by circulating inhibited acids or other solvents.

Research

Constantly changing operating conditions increase the difficulty of fighting corrosion. Each batch of sour crude generally varies from the preceding one and requires special treatment. Circulating sea water, especially from harbors or at the mouths of rivers, tends to become more corrosive.

Operating engineers recognize that there is a difference in the behavior of various metals and often have one or more installations in trouble spots designed for experimental purposes.

Instead of using tubes of one alloy, three or more different kinds of alloys are installed in the tube bundles, properly identified, so that individual ones can be pulled out from time to time for examination. Results obtained are helpful in determining which alloy should be used when retubing. (6709)



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Tenamene is Eastman's brand name for gasoline additives.

THERE'S TENAMENE 1—N-butyl p-aminophenol—48% solution in isopropanol—a gum inhibitor

AND TENAMENE 2—di-sec-butyl p-phenylenediamine—also a gum inhibitor

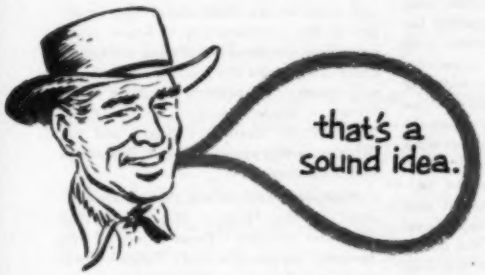
AND TENAMENE 60—disalicylal propylene di-imine (80% solution in toluene)—a copper deactivator.

Yes sir! We ought to know—we've been making them for almost fifteen years.

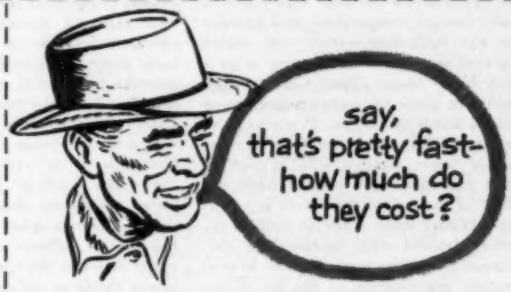
Practically every refinery in the United States and many abroad.

That's because they were sold through another company under its own trade name.

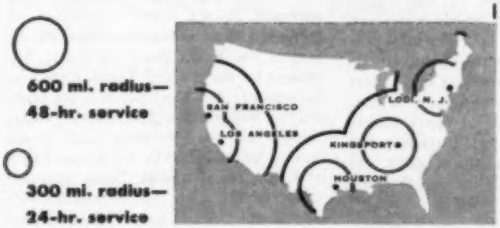
It means that you can now get these gasoline additives directly from the basic manufacturer.

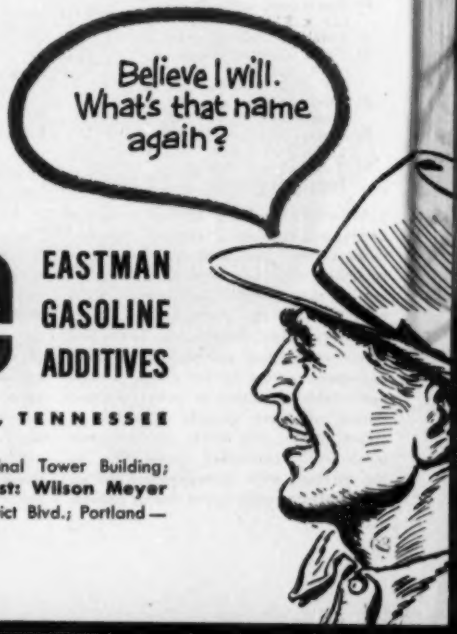


Sure it is! We're set up to give you top service, too. Here's the delivery story.



That depends on how much you order and what part of the country you're in. Tell you what—write to one of our sales representatives* or to Kingsport, Tennessee. They'll be glad to give you prices, specifications, send samples and any other information.





Tenamene

EASTMAN GASOLINE ADDITIVES

TENNESSEE EASTMAN COMPANY, KINGSPORT, TENNESSEE

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Figure 3. Atmospheric deck-type cooling towers may be used with or without coil systems. Tower on right has heat exchanger coils in inclosed section at base.

liminary structural, mechanical and electrical data for a cooling tower to handle a certain condensing requirement, simple specification of heat load, desired water rate and temperatures and ambient air wet bulb temperature will enable the cooling tower manufacturer to prepare basic design data. Consideration should be given to tower proportions of length, width and height. Prevailing and next-prevailing wind direction may influence tower location with respect to plant and equipment position when the effect of downwind saturation is evaluated. Winter icing of the air intakes deserves detailed study in the same consideration with ice formation due to condensate precipitation to the lee of the structure. For the evaluation of cooling tower bids on a complete installation, tabulation of primary factors, at average values of cost, may be made as follows:

1) Total average demand of fans and pumps.....kilowatts
2) Basin area .....square feet
3) Capacity cost, Item (1) x $1.75.....$
4) Basin cost, Item (2) x $2.50.....$
5) Total installed bid price.$
6) Total Capital Investment, Items (3) plus (4) plus (5).....$
7) Annual fixed charges, Item (6) x .075.....$
8) Energy charges, Item (1) x 7000 x .004.....$
9) Total annual charge, Items (7) plus (8).....$

Although the basic specifications for cooling towers should contemplate maximum turbine load and maximum heat rejection from the condenser, it is essential that partial load operation be considered in the selection of cell arrangement, fan diameters, fan drives and water circulating pumps. The use of two-speed motors for fan drives permits appreciable reduction in power demand during off peak periods. The use of steam turbine fan drives permits thermostatically controlled steam flow to the turbines with corresponding reduction in steam requirement during periods of low wet bulb temperature or off-peak demands. Recent developments in the hydraulic speed reducer field indicate definite possibilities for such applications with resultant economy. Partial load operation must be carefully studied for each particular condenser-turbine unit to make certain that the loss in vacuum resulting from the increase in entering water temperature or temperature rise within the condenser does not offset the power saved by reduction in cooling tower fan loading. Flow control on water circulating pumps deserves particular attention when we consider that the volume delivery of the centrifugal pump varies as the speed and the horsepower varies as the cube with the head varying as the square of the speed and a resultant power saving of only 45 percent at half speed operation is realized.

"Closed" Systems

In the small diesel or gas engine driven generator plant, jacket water and lube oil cooling can be efficiently handled by "closed" systems utilizing atmospheric or shell and tube heat exchangers in conjunction with raw water circulation over spray ponds or spray towers if space is available and driftage is not objectionable. In the larger units, the waste heat may be dissipated efficiently by an induced draft cooling tower.

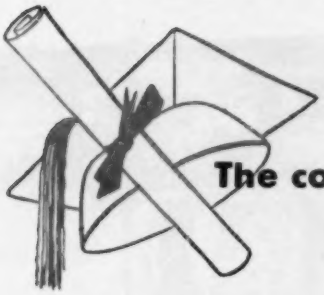
In locations of high water cost or unavailability of dependable water supply, the recently developed air-cooled heat-exchangers fulfill the requirement. These air-cooled units were gradually developed from the automobile radiator type of heat exchanger. Utilizing the mechanical equipment developed for cooling towers, the air-cooled devices are designed to force or induce a flow of ambient air over the extended tube surface developed by "fins" wrapped around or drawn out of a heavy wall tube through which the treated circulating water is pumped. Efficient designs of finned tubing often deliver 2.5 times the capacity of plain tube surface per square foot of effective external area.

Without the advantage of latent heat phenomena utilized in cooling tower function, the air-cooled exchangers, dependent upon dry bulb temperatures of the ambient air, compare favorably in total annual charges with the cooling tower installations on the internal combustion engine driven generators. With 100° F. dry bulb air passing through the finned tubing 140° F. water temperature can be achieved efficiently. Obviously the economy of the air-cooled designs is lost when the temperature requirements fall close to or below the ambient dry bulb temperature.

With 8 of our 48 states presently controlling the use of surface and underground waters within the state by legislative regulation and with 131 major cities preparing to answer the problem with local regulation governing the use and waste of water, thorough investigation of water conservation procedures will soon be standard engineering practice in the consideration of power plant operation, expansion, annual operating costs and plans for ultimate plant requirement. The pattern for state regulation is already defined by the Ohio State Water Resources Board and the Minnesota Division of Water Resources and Engineering.

Statistical data on the subject are outlined in the Hoover Report of 1949 pamphlet entitled "Department of the Interior" and in the Task Force reports on Water Resources Projects (Appendix K) and Public Works (Appendix Q). Basic geological data is available from the U. S. Department of the Interior in "Publications of the Geological Survey" dated May 1948. Pioneers in the approach to the water problem have published their findings in the 19th report of the Texas Board of Water Engineers for the State of Texas. Collateral data on a typical local situation are available in Bulletin No. 5101 on the Water Supply of the Houston Gulf Coast Region as published by the Texas Board of Engineers at Austin, Texas, prepared cooperatively with the Geological Survey of the U. S. Department of Interior in January, 1951. The President's Water Resources Policy Commission has published a summary of recommendations for a "Water Policy for the American People" in which is stated the broad framework of a principle proposing a reformulation of water resources as a Federal function.

It is to be hoped that the foresightedness of the power industry in its judicious use of efficient water conservation devices may so minimize the requirement of federal action that major emphasis may be placed upon the preservation of our greatest natural resource rather than upon the regulation of its use in the production of energy.



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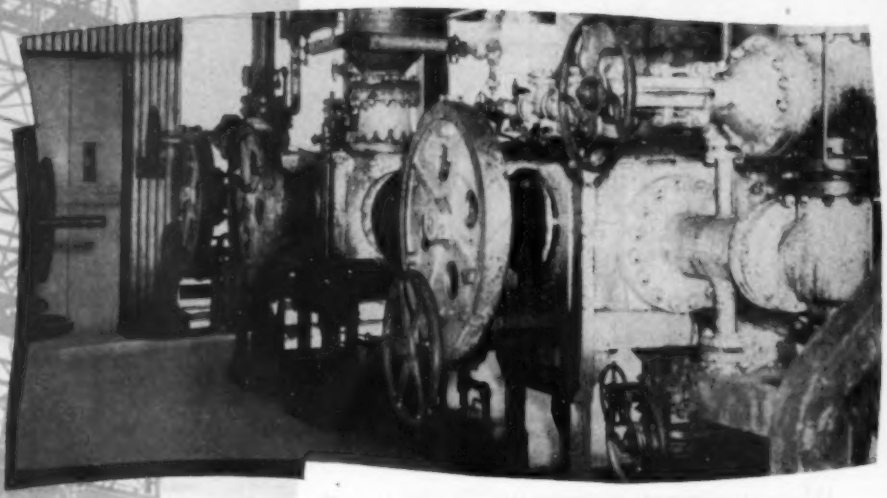

• The master Switch Valve in the center has one inlet and three outlets. Valves on each side have one inlet and two outlets and each one serves a coke drum. This combination readily controls the continuous flow of the charge from the coke furnace.

—distribute reduced crude to the coke drums in PAN-AM SOUTHERN'S El Dorado Refinery new coking unit.

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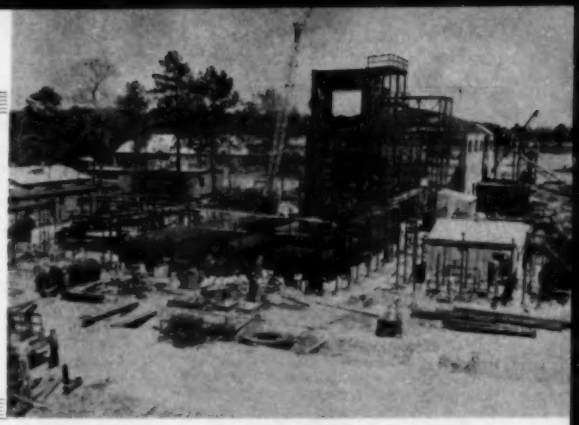
News Notes on Refinery and Other Plant Construction

Petroleum Refiner's Next "Box Score". Tabulation Will Appear in the July Issue



Continental Oil Black Company's Louisiana plant takes shape.

NW Expands on Promise of Canadian and Dakota Oil

A multi-million dollar expansion program to more than quadruple the capacity of Northwestern Refining Company's St. Paul Park, Minn., oil refinery has been granted a $2 million certification of necessity by PAD. Company officials explain this sum will cover only initial phases of the project which has been undertaken in the bright promises of oil from Canadian fields as well as the opening of a new field in North Dakota.

Arthur Erickson, president of Northwestern, said a pipe line is being considered to link the Twin Cities with Superior, Wis., present depot for Canadian oil.

Plans are to increase the refining capacity from 8000 to 30,000 barrels daily. One aspect of the expansion will be the construction of a catalytic cracking plant to manufacture high octane aviation gasoline.

Firestone and CS Plan Lake Charles Chem Plant

A plant to encompass the broad fields of plastics, synthetic rubber, additives for lubricating oil, cracking catalysts, anti-freeze and many high volume petrochemicals will be built at Lake Charles, La., by the newly formed American Petrochemical Corporation, according to Harvey S. Firestone, Jr., chairman of the board of the Firestone Tire and Rubber Company, and W. Alton Jones, president of Cities Service Company.

Lake Charles is being considered as a possible site because Cities Service's 160,000-barrel refinery there would be a source of light hydrocarbons for the chemical plant. In addition, Firestone operates an adjacent government-owned synthetic rubber plant.

Pemex Program Includes Five Building Projects

Petroleos Mexicanos has completed engineering and purchasing arrangements for erection of a desulfurization plant at Atzcapotzalco and expects to have the plant in operation by November. The unit will have a daily capacity of 12,000 barrels and is estimated to cost $995,000. Perco Division of Phillips Petroleum Company has licensed the process and engineering will be handled by Phillips, A. G. McKee & Company and the Petroleos Mexicanos staff. McKee has been given the contract for construction work.

A new refinery on the west coast of Mexico still is in the planning stage. It would have a daily capacity of 30,000 barrels and would cost about $13 million.

The desulfurization plant at Poza Rica is still under consideration. If built, it will have a daily capacity of 3000 barrels and will cost about $400,000; Perco Division will license the unit and engineering will be handled by Phillips and Pemex. Pemex will do the building.

Engineering and purchasing for the Ciudad Madero desulfurization plant is concluded and Pemex hopes the $1,460,000 plant, with a capacity of 12,000 barrels a day, will be finished before 1952. Again Perco has licensed the unit; engineering will be carried out by Phillips and McKee as well as the Pemex staff. McKee will build the unit.

Contract has been awarded the McKee company to engineer and build the lube plant announced earlier for Pemex's Salamanca refinery. Daily capacity of the unit will be 2400 barrels lube oils, and 140,000 pounds of paraffin waxes.

3570 BPD Bayou On Stream Spraberry Plans Develop

Phillips Petroleum Company just completed construction of its Bayou plant in Brazoria County, Texas, and has announced it will start work on another natural gasoline plant south of Midland, Texas, in the immediate future.

Bayou plant, in the Chocolate Bayou field, went on stream this month after being under construction for eight months. Treating 175 million cubic feet of gas, its natural gasoline products capacity is 3570 barrels daily. Gas is gathered from both distillate and oil wells by a dual gathering system.

Plant designs are developing rapidly on the new Spraberry plant which will be built south of Midland, in the Tex-Harvey, Germania and Driver areas. Phillips owns or has contracted oil rights for 26,000 acres surrounding the site and plans to build a line to connect with the Permian Basin gathering system to assure the plant a steady outlet for its natural gasoline and LPG production.

Pure Announces Expansion

The Pure Oil Company has two refinery expansion projects on the drawing board. One project would expand its 60,000-barrel-a-day plant at Nederland, Texas. The second project is addition of a catalytic cracking plant to the Toledo, Ohio, refinery which at present has a capacity of 30,000 barrels a day. Contracts have not been awarded.

Furnace Black Plant at Westlake About Finished

The new $2 million Continental Oil Black Company plant for the production of high abrasion furnace black from oil, begins to take shape (photo above) at Westlake, near Lake Charles, La. The new plant with an annual capacity of 25 million pounds, is a joint enterprise of Continental Carbon Company and Continental Oil Company. Rise in the use of synthetic rubbers, especially "cold rubber" has increased substantially the demand for high abrasion furnace black. It is anticipated the plant will be in production sometime this month.

Output of the new plant will be distributed by Witco Chemical Company.

Benzene Plant Project Underway at Shreveport

Construction on the $3,300,000 expansion program at Atlas Processing Company's Shreveport, La., plant for production of benzene got underway last month. Approximately 17,600 gallons daily of benzene will be produced when the plant is finished early in 1952.

An attractive distillation unit for benzene recovery has been designed by Shell Development and UOP designed the Platforming unit which will be among the major facilities installed. Hudson Engineering Corporation will construct this distillation equipment while Procon, Inc., will build the Platforming unit.

Feed stocks for Shreveport facilities will be natural gasoline from several nearby gas processing plants.

Crude Distillation Unit Added to Geelong Refinery

Construction work on Australian Shell Company's new crude oil distillation plant at Geelong, Victoria, is scheduled to begin soon. When the plant is completed sometime near the end of 1953, the 250-acre plant will have an eventual output of one million tons annually. Prime purpose of the plant will be to reduce Australia's dollar shortage. Feed stock will be obtained from British Borneo.

Initially, volume will equal 750 thousand tons annually. The output will include 163,200,000 gallons of gasoline, 45,600,000 gallons of fuel oil, and 27,600,000 gallons of Diesel oil. The Geelong distillation plant will be twice as

large as the Shell refinery at Clyde, New South Wales; storage capacity will ultimately equal 67,200,000 gallons. Electric power will be generated on the plant site, making it independent for outside power.

55,000-Barrel Vac Flasher At Richmond Nearly Finished

Construction of Standard Oil Company of California's 55,000-barrel-a-day vacuum flasher at Richmond is more than 75 percent complete, according to The M. W. Kellogg Company. Scheduled to go on stream by the middle of July, the unit is designed to provide approximately 30,000 barrels of feed each day for the existing catalytic cracking unit. The cracker is being revamped during a general modernization program.

The main vacuum flasher tower will have an over all height of approximately 100 feet and a maximum diameter of 27 feet. Its design capacity is believed to exceed by 15 percent the largest vacuum unit currently in operation. Asphalt which comes off the flasher as a bottom product will be charged to visbreakers to produce gasoline and high quality fuel oil.

Texas Plant to Extract Sulfur from Natural Gas

Construction of a large sulfur extraction plant near Goldsmith, Texas, in the Permian Basin oil fields, was underway this month for Phillips Chemical Company. The plant is designed to extract from natural gas nearly a quarter of a million pounds of elemental sulfur per day. The output will be used by the company in connection with its ammonium fertilizer plant at Adams Terminal near Houston. The company said that limited reserves of elemental sulfur make it necessary to utilize other sources in the face of ever increasing demand.

Butadiene Plant at Kobuta To Work Maximum Capacity

Fourth and last butadiene unit of the government-owned plant at Kobuta, Pa., will be reactivated by the Chemical division of Koppers Company, Inc. This unit, like the others has been in standby condition since World War II. The Korean emergency caused the government to order two units reactivated and later a third was reopened to take over for a fire damaged unit. It will be several months before the last unit will be ready for operation. Monthly capacity for all four units is rated at about 20 million pounds.

Sulfur Unit Announced

Continental Sulphur & Phosphate Corporation has announced plans to construct a sulfur extraction plant at the site of its ore holdings in the Sunlight Basin area near Cody, Wyo. Construction will begin as soon as financial arrangements are concluded. Chemical Construction Corporation, N. Y., a wholly-owned subsidiary of American Cyanamid Company, has submitted contracts for the facilities.

Lake Charles Plant OK'd For $24 Million Expansion

Capacity of Continental Oil Company's Lake Charles, La., refinery will be increased from 12,000 to 40,000 barrels daily upon completion of the $24 million expansion program which has been approved for tax exemption by Louisiana Governor Long. Last fall Continental announced a $10.5 million program, but operations were scaled upward "due to increasing military and civilian demands." Construction work on the project got underway this month with Badger & Sons of Boston awarded most of the engineering and construction work.

Among the process units being added to the refinery are a crude distillation unit; catalytic cracking, reforming and polmerization units; gas recovery, and a solvent extraction unit to separate benzene and toluene. The existing alkylation unit is being revised and enlarged to provide for production of approximately 3600 barrels daily of alkylate, an increase of nearly 3000 barrels.

Auxiliary equipment to be erected will include steam and electricity generation facilities, enlarged dock facilities on the Calcasieu River, and other offsite facilities.

Selected crude oils will be segregated and especially processed to produce a high quality residuum which will be pumped to Cit-Con Oil Corporation's nearby plant for manufacture of high viscosity index lubricating oils. A highly aromatic feedstock, particularly constituted for the purpose, will be produced and furnished to the Continental carbon black plant now under construction adjacent to the refinery.

Gas-Benzene Production To Be Increased by Shell

Plans for the $12 million platforming unit announced previously for Shell's Deer Park refinery near Houston have been altered to meet a growing demand for benzene and toluene. The unit will be converted to a benzene plant, Shell Oil Company's second, and will produce about 19 million gallons of benzene and 38 million gallons of toluene concentrates a year.

As raw material, the plant will use a gasoline fraction in the distillation of crude oil. This will be put through a platforming unit, which will process it at a temperature of about 900° F. and a pressure of about 250 psi., in a hydrogen atmosphere and in the presence of a catalyst containing platinum.

Company officials say the plant pioneers a significant trend in benzene production, viz., away from the use of coal by-products to the use of petroleum as raw material. Development of this trend has been necessitated by the ever increasing demand for benzene while the supply that can be derived from coal by-products is fairly constant.

Procon, Inc. will build the platforming unit, Foster Wheeler Corporation, the aromatics concentration section.

30,000-Barrel Increase Slated for Sugar Creek

Capacity of the Standard Oil (Indiana) refinery at Sugar Creek, Mo., is to be increased from 38,000 barrels-a-day to 68,000 by the end of 1952. Major unit to be installed in the program to enlarge gasoline and kerosine facilities, will be a crude-running and coking unit which will be located adjacent to the catalytic cracking and vapor recovery units installed in 1948. Construction work will commence this fall, with project completion scheduled for the late 1952. Contract awards have not been announced.

ECA Spending $35 Million On W Europe Refineries

Fourteen petroleum refineries are being modernized, expanded or constructed in Western Europe with the aid of Marshall-Plan financing in projects approved in the last three years in the area's reconstruction effort. The estimated total cost of the refinery projects are the equivalent of $234,609,000, of which $35,142,000 is Economic Cooperation Administration dollar financing.

Eight refineries in France are being rebuilt and modernized at a total cost of $122,605,000, of which the ECA is providing $16,633,000. Two plants in the United Kingdom are being expanded to process more crude oil from the Middle East at a total outlay of $82 million, of which $9,705,000 represents ECA funds. Equipment for improving the quality of gasoline produced at three Italian plants is being added at a cost of $21,334,000, of which the ECA is putting up $8,134,000. One new refinery is scheduled for construction at Lingen, Germany, costing $8,670,000, of which $670,000 is Marshall-Plan funds.

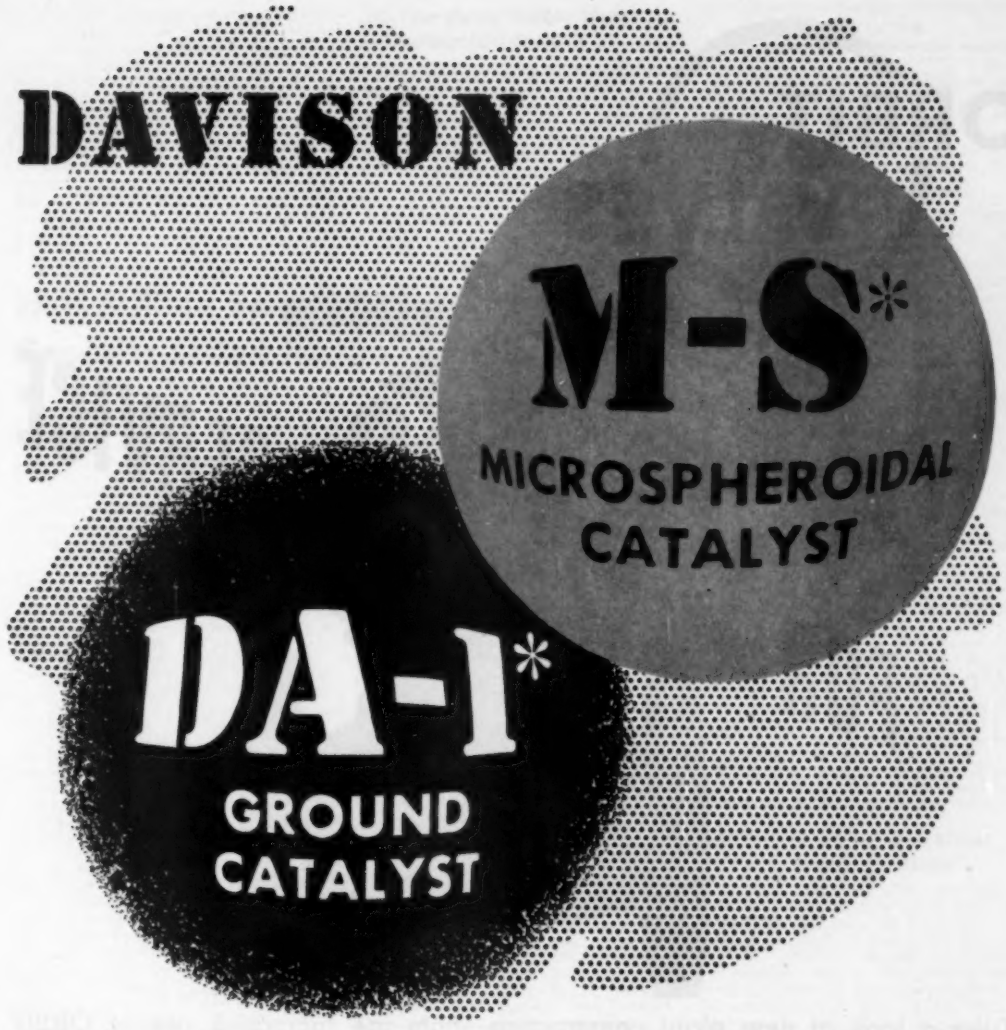
A breakdown of Western Europe's ECA-aided refinery projects follows:

ECA Petroleum Refining Projects and Total Capacity Output After Expansion

	1952-53 Throughput (Thousands of Metric Tons Per Year)	(Thousands of Dollars	
		Total Cost	ECA Cost
FRANCE			
Standard Francaise des Petroles (SEP), Port Jerome:	2,095	$10,000 6,415	$1,750 1,428
Campagnie Francaise de Raffinage (CFR), La Mede and Gonfreville:	5,000	10,000 11,000	2,880 3,180
Socony-Vacuum Francaise Notre Dame de Gravenchon:	800	6,000	850
Raffineries Francaise de Petrole de L'Atantique, Donges:	1,000	9,435	730
Societe Generale des Huiles de Petrole (SGHP), Dunkirk:	1,400	38,106	4,005
Compagnie de Raffinage Shell Berre, Berre:	2,500	31,680	1,580
GERMANY			
Gewerkschaft Erodel-Raffinerie Emsland, Lingen:	600	8,670	670
ITALY			
Aquila, S.P.A., Tecnico Industriale, Zaule:	500	7,980	4,250
Societa Permolio, Rome, Genoa and Milan:	240	4,984	1,534
IROM (Societa Raffinazione Olli Minerali), Porto Marghera:	950	8,400	2,350
UNITED KINGDOM			
National Oil Refineries Limited, Llandarcy Refinery, South Wales, England:	2,135	48,000	7,250
Shell Refining and Marketing Co., Ltd., Shell Haven Refinery, England:	2,300	34,000	2,455

Kellogg Awarded Contract For Ferrara Olefin Plant

The Economic Co-operation Adminis-



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tration will underwrite about 15 percent of the cost of an olefin plant to be erected at Ferrara, Italy, for the Montecatini Company. Total construction cost will run about $18,670,000, but ECA has obligated itself only for the cost of certain American processes, and for payment of American engeneering services. The M. W. Kellogg Company has been awarded both engineering and contracting contracts. The plant, which will have a daily capacity of about 450 barrels will go on stream mid-summer 1953.

50-Ton Daily Sulfur Unit Is Contracted for CCI

Consolidated Chemical Industries, Inc., will build a 50-ton-per-day sulfur plant at Baton Rouge, La., which will process "acid gas" from desulfurization units at the nearby refinery of Esso Standard Oil Company. Ralph M. Parsons Company, Houston, was awarded the engineering and construction contracts. Initial production of the completed plant will amount to approximately 34 tons daily.

Half Million Barrels Daily Added Crude Capacity Listed for Quick Amortization

A total of 527,966 barrels per day of crude running capacity will have been added to U. S. capacity upon completion of basic refining facilities recommended for accelerated amortization, according to a report issued to Congress by PAD last month. Total cost of construction amounts to $422,990,803. PAD advised Congress it would not recommend marketing facilities for fast tax write-off until "such time when they are determined necessary for national defense and a shortage can be established."

Crude oil topping projects recommended for fast tax amortization and not previously listed in this magazine are: Gulf Oil Corporation, Philadelphia, $40,596,740; Puerto Rican Refining Company, Puerto Rico, $13,385,000; Standard Oil Company of California, Richmond, $9,000,000; Great Northern Oil Company, St. Paul, Minn., $22,550,000; Southwestern Oil & Refining, Corpus Christi, Texas, $5,520,000; Socony-Vacuum, Buffalo, N. Y., $4,588,000; Union Oil Company, Edmonds, Wash., $1,000,000. In addition, the Great Northern Oil and Puerto Rican Refining were granted fast tax write-offs for aviation alkylate facilities involving investments of $3,525,000 and $4,350,000 respectively.

Other refineries to be granted certificates of necessity for basic oil refining facilities, and not previously announced in PETROLEUM REFINER, are The Pure Oil Company, at Smiths Bluff, Texas, $10,750,000. Phillips Petroleum Company, Sweeney, Texas, $4,787,200, 75 percent. Mercury Oil Refining Company, Oklahoma City, $3,195,000.

New Mexico Unit

New Mexico Asphalt & Refining Company, Artesia, N. M., 3000-barrel crude topping unit, a 6000-barrel catalytic cracking unit, and a 300-barrel-a-day catalytic polymerization unit, $1,957,000, 75 percent.

Kendall Refining Company, Bradford, Pa., catalytic reformer with capacity of 1500 barrels, $913,671, 75 percent. Lion Oil Company, Eldorado, Kans., increasing output of aviation alkylate by 432 barrels, $810,000, 100 percent. Shell Oil Company, Wood River, Ill., boosting toluene output by 255 barrels, $150,000, 100 percent. Koppers Company, Kobuta, Pa., styrene monomer, $4,011,267, 70 percent. The Dow Chemical Company, Freeport, Texas, styrene, $1,610,000, 70 percent. Monsanto Chemical Company, Texas City, styrene monomer, $8,600,000, 70 percent. Dewey and Almy Chemical Company, Cambridge, Mass., synthetic rubber, $404,000, 70 percent.

New in the list granted certification for projects pertaining to special alkylation feed facilities and aviation alkylates at 100-percent amortization are The Pure Oil Company, Smiths Bluff, $390,000, and Phillips Petroleum Company, Sweeney, Texas, $3,630,200.

Increase in Benzene

Fifteen projects already approved by PAD are estimated to cost $26,700,000, will add about 18,700 barrels-a-day of aviation alkylate to the country's production of octane booster. Benzene production is estimated to be increased by 63,600,000 gallons-a-year by ten projects underwritten for fast tax amortization at a cost of $25.8 million.

Largest single basic refining projects to be granted certification were the expansions scheduled for the California Refining Company of Perth Amboy, N. J., with a 75 percent write-off on $29,366,261, and Sinclair Refining Company with 75 percent certification on $27 million.

Projects scheduled for fast tax amortization in oil-allied industries are: Southland Oil Corporation, Savannah, Ga., storage terminal, $450,080 at 70 percent; Terminal Oil Company, St. Louis, oil barges, $160,000, 80 percent; Alamo Water Transportation Company, Houston, oil barges, $233,600, 80 percent; American Smelting & Refining Company, Corpus Christi, Texas, sulfuric acid, $700,000, 70 percent; and Garfield Chemical & Manufacturing Corporation, Garfield, Utah, sulfuric acid, $3,583,000, 70 percent.

Refining Programs Net Ten Percent of Tax Write-offs

Approximately ten percent of all industrial expansion programs certified by the government for fast tax write-offs represented refining projects according to an industry-by-industry summary compiled by the Defense Production Administration. Total oil refining eligible for fast tax write-off was $368,300,000 of a grand total for all industries of $4,709,000,000.

Average percentage granted refining projects certified for rapid amortizations was 79 percent, while the average for all other industries was 69.1 percent. The only projects receiving higher percentage certifications were: coal, coke and iron ore, 82.6; refractories and materials, 84.2; automotive equipment and components, 81.1; ordnance, tanks, guns and ammunition, 83.9; and guided missiles and rockets, 80.4.

El Paso Refinery to Get Cat Cracker, Other Units

Standard Oil Company of Texas, granted a $10,264,000 certification for fast tax write-off, will install a 11,000-barrel-a-day Houdry catalytic cracking unit at its El Paso refinery. Other units to be added are an alkylation unit, a vapor recovery unit, a reduced crude vacuum flasher, and synthetic distillation and treating units. Catalytic Construction Company will build the cat cracker. The unit is expected to go on stream about July 1, 1952. The refinery now process about 18,000 barrels of crude daily.

Construction Begun On Canada's Largest Cat

Construction work on Canada's largest Fluid catalytic cracker has been started by The M. W. Kellogg Company.

The 25,000-barrel-a-day cracker is part of an over-all modernization program being undertaken by Imperial Oil, Ltd., at its Sarnia, Ontario, refinery.

Kellogg, through its subsidiary, Canadian Kellogg Company, Ltd., is also scheduled to build a 46,500-barrel-a-day, two-stage vacuum and atmospheric distillation unit, as well as a light ends recovery system. The capacity of the distillation unit is also believed to be the largest in the Dominion.

When the equipment is on stream, the refinery's capacity will be increased by 30 percent, or to 71,000 barrels daily.

California Union Develops "Hydrodesulfurization"

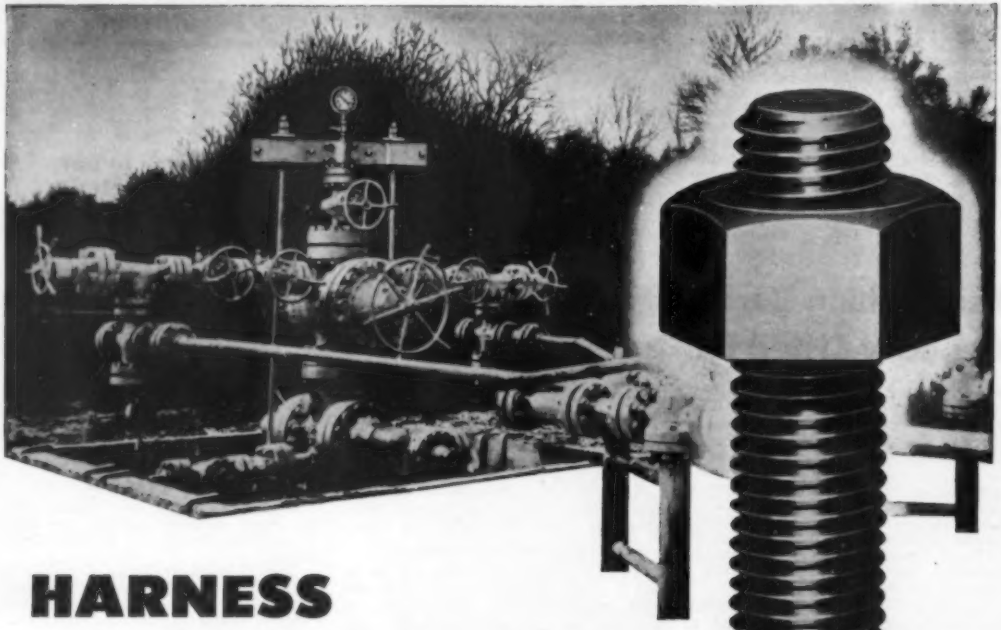
"Hydrodesulfurization," a new catalytic cracking process developed by Union Oil Company of California, is being considered for installation at Union Oil Company's 65,000-barrel-a-day Wilmington refinery. The process was developed, officials said, specifically for the processing of Santa Maria crude fractions.

The process utilizes a newly developed catalyst and operates on the moving bed principle. Hydrogenation and desulfurization of heavy, sour charge stocks is involved in the "Hydrodesulfurization" method.

West Coast Plant Restored

Restoration of the Santa Maria, Calif., refinery owned by Sunray Oil has been completed and the plant is back on stream turning out 5000 barrels per day of motor gasoline, kerosine distillates, and other allied products. An explosion in June, 1950, destroyed nearly 75 percent of the processing facilities.

Reconstruction work included addition of a new crude fractionating tower designed to process 4000 barrels of crude daily, a new distillate stripper tower, a Fluor fin-fan product cooling unit, two Fluor atmospheric cooling towers, a viscosity breaking unit fractionating tower and other smaller units.



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PETROLEUM
REFINER
JUNE, 1951

Many Improvements Noted in Alkylation Plant Design

D. H. PUTNEY
Vice President, Stratford Engineering Corporation, Kansas City, Mo.

THE YEARS 1940 through 1945 witnessed the development of alkylation from a laboratory process to an industry of enormous capacity for the production of aviation gasoline. During those years the push for more and more installed plant capacity led toward standardization of plant designs and away from experimentation or design changes. The years 1946 through 1950 saw a decline in the demand for alkylate and little incentive for spending money to improve the process or increase the capacity of existing plants. With the demand for alkylate again rapidly increasing it is fitting that a critical study of existing plants be made to determine how best to increase production, also to design any new installations guided by experience of the past ten years so that the required quality and capacity are obtained at minimum cost and with the minimum amount of steel, labor and time. To assist in such study is the purpose of this article.

WITH a huge defense program in the making, a new aviation gasoline situation has arisen. Not only must the refining industry be in position to supply enormous quantities of aviation fuel but it must be able to produce this fuel to specifications much higher than during World War II. Advances in aircraft engine design now make it necessary to supply a major portion of the aviation gasoline as 115/145 grade. The components of this grade are principally isopentane, alkylate and aromatics. The blending of 100/130 grade aviation fuel normally requires only from 25 to 35 percent alkylate, and considerable alkylate produced from olefins other than butylenes may be used. In the blending of 115/145 grade however, from 70 to 80 percent alkylate is required and this alkylate must be of high quality in order to meet the 145 rich mixture index. Such alkylate must be produced for the most part from butylenes, although as aromatic blending components become available more propylene alkylate may be worked into the blends. In all cases however, it is desirable to improve the octane rating of the alkylate so that it will make a greater quantity of finished blend.

With both increased quantity and quality of alkylate required to meet our defense demands it is evident that not only must new alkylation plants be built to utilize available feed stocks but also the existing units should be altered or "modernized" to step up the quality and/or quantity of alkylate where this can be done without large capital investment. Recent process and mechanical studies of alkylation plant reactor sections have disclosed a number of ways in which new alkylation plants may be built better and at lower cost than previous units, and ways in which existing reactor sections may be modified to increase capacity and/or quality with moderate capital outlay. These improvements apply to both the sulfuric acid and the hydrofluoric acid processes. To avoid possible confusion the two processes are discussed separately in the following:

HF Alkylation

Improvements in Existing Plants

All existing commercial HF alkylation plants are equipped with Contactor reactors constructed as shown diagrammatically in Figure 1. There were 78 of these reactor units installed during World War II. A few have been dismantled but the great majority are either now operating or could easily be rehabilitated and placed in service. Most of these units are water cooled, as shown in Figure 2, while a few are equipped with mechanical refrigeration, as shown in Figure 3. All of these plants were built in the haste of getting the World War II aviation gasoline program under way and they were all under construction before appreciable data and experience were available from the first commercial units. It was thought at the time the units were designed that a reaction time of about 20 minutes was required for HF alkylation similar to that required in the sulfuric acid process. Now, however, it is recognized that 8 to 10 minutes is ample time to complete the reaction. It therefore becomes possible to put 2 to 2½ times as much composite feed to most of the existing reactors and still have ample reaction residence time. The problem becomes one of heat removing capacity since such an increase in feed rate will also increase the load on the Contactor tube bundle by 2 to 2½ times. The

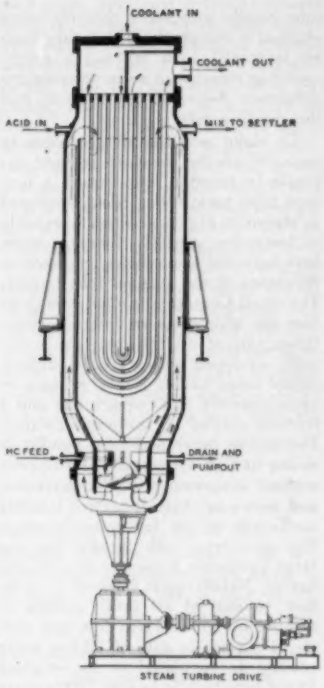


Figure 1. Vertical Contactor, Lance Type Tube Bundle.

tube bundle with which the units were originally equipped will not take such an increased load without a corresponding increase in mean temperature difference between the coolant and the reaction mix.

To make possible the increase in capacity of the reactors without increase in reaction temperature a new type tube bundle has been developed as shown in Figure 4 which is capable of removing over 2½ times as much heat with the same mean temperature difference as the original tube bundle. The small Contactor reactor, known as Size 30, which has an internal circulation rate of 30,000 gpm, was originally equipped with extended surface finned tubes having a total surface of approximately 4300 square feet and a transfer rate of 25 for water cooling. The newly developed tube bundle as shown in Figure 4 consists of all prime surface in amount of 4100 square feet and shows an over-all service transfer coefficient of 90 for water cooling. The new type tube bundle for the large Contactor, known as Size 50 and having 50,000 gpm internal circulation, consists of all prime surface in amount of 6600 square feet and also shows a transfer rate of 90 for water cooling as compared to the original finned tube bundle having 7700 square feet of extended surface and showing a transfer rate of ony 25.

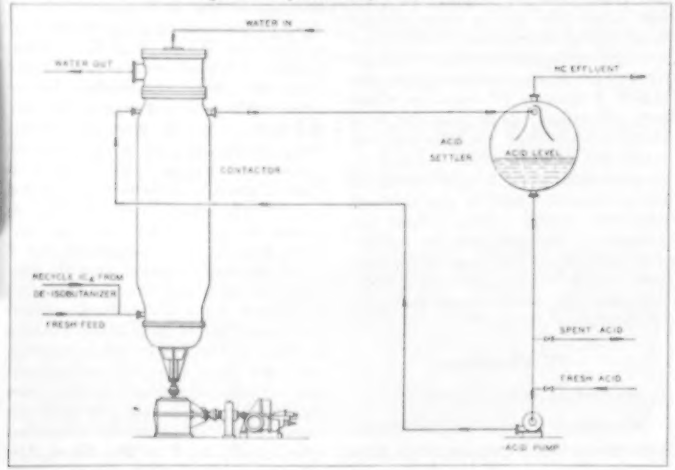
All the new type bundles for both sizes of Contactors consist of U-tube elements constructed of 1" o.d. No. 11 Bwg. seamless tubing without welds or joints except where rolled into the tube sheet. The elimination of all welded joints and welded plugs in the tube bundle elements is a definite advantage since nearly all of the tube failures in the past have occurred at welds.

Aside from the ability of the new type U-tube bundle to make possible a large increase in capacity for existing Contactor reactors there is its ability to lower the reaction temperature in cases where the feed rate is either not increased or is increased to less than 2½ times the original feed rate. In units where the feed rate remains as originally designed the new tube bundles will remove the heat with a mean temperature difference of only approximately 40 percent of the original design figure. This is of particular significance in the light of recent findings that as the reaction temperature is decreased in the HF alkylation of butenes, the F4 rich mixture index number of the alkylate is increased, at least in the operating range from 110° F. down to 60° F.

On present water cooled units where the application of mechanical refrigeration is being considered to further decrease the reaction temperature, the new type bundle offers a means of reducing capital investment costs and operating costs in the refrigeration plant. The original tube bundles with finned tubes realized a service transfer coefficient of only 20 on propane refrigeration applied to the 4800 square feet of extended surface in the Size 30 Contactors and 7700 square feet in the Size 50 Contactors. The new type U-tube bundles show a service transfer rate of 60 on propane refrigeration applied to 4100 square feet of bare surface in the Size 30 Contactor and 6600 square feet in the Size 50.

The U-tube bundle is interchangeable with the original bundle. Existing channel and channel cover can be used by simply installing a baffle plate in the channel. Where water cooling is used this is the only change required.

Figure 2. Alkylation Unit, Water Cooled.



In cases where mechanical refrigeration is to be used it is necessary to pump the refrigerant through the tube bundle as shown diagrammatically in Figure 5. A number of manufacturers offer standard pumps for this service, circulating a large quantity of refrigerant at very low head and requiring only about 3 to 5 hp. per Contactor. The original finned lance type tube bundle required no refrigerant pump since flow could be established by the difference in density of the down-flowing all-liquid refrigerant stream in the lance tubes and the up-flowing vapor liquid mixture in the annular spaces between the lance tubes and the finned outer tubes.

New HF Alkylation Reactor Systems

The original HF alkylation Contactors with which all plants built during World War II were equipped were vertical units as shown in Figure 1. These contactors required considerable structural steel for support and for servicing. The amount of this structural steel approximated 30 tons for a single Size 50 Contactor or 50 tons for a two Size 50 Contactor plant. Moreover, the drives of these machines involved the use of both parallel shaft reducing gears and right angle gears. This necessitated the setting and alignment of four pieces of machinery—Contactor, right angle gear, parallel shaft gear and turbine.

The new type Contactor is a horizontal machine as shown in cross section assembly in Figure 6. It is mounted directly on a concrete foundation in steel saddles which are made a part of the Contactor shell. The only structural steel required is a small amount in the form of trolley beams and their supports for use in pulling or reinserting the tube bundle at one end of the Contactor and for removing the hydraulic head at the other end. To install this servicing steel permanently for each Contactor requires only about 7 tons per machine for the Size 50 and 6 tons per machine for the Size 30.

The drives for the horizontal Contactors are greatly simplified. In the case of motor driven units gears are eliminated and the drive is by means of an explosion proof motor directly connected to the Contactor shaft through a flexible coupling. Drive for the Size 30 Contactor is a 900-rpm. motor, and for the Size 50 a 514-rpm. motor. In the case of turbine driven Contactors it is of course necessary to employ reducing gears for best turbine efficiency, but these are simple parallel shaft gears and the right angle gears used on the old vertical units are eliminated.

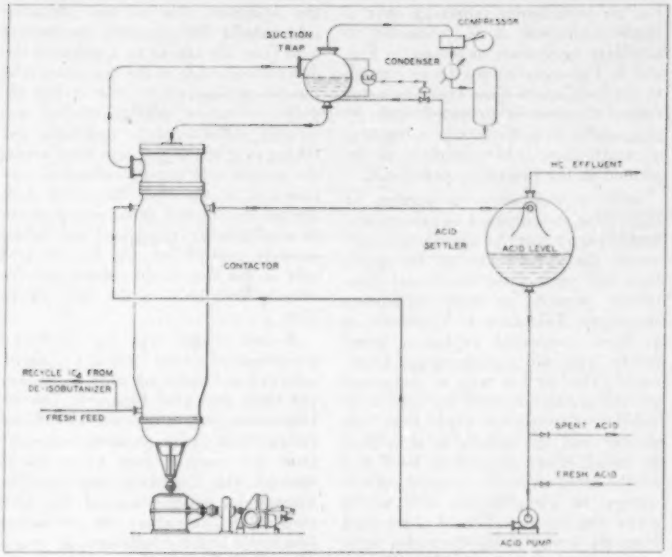


Figure 3. Refrigerated Unit, Lance Type Tube Bundle.

Not only is the equipment cost of the new type Contactor and drive considerably less than the old vertical type unit but there is also a considerable saving in erection costs. Foundations need not be spread to the extent required for the previous tall structures with wind loads. Approximately 18 to 23 tons less structural steel are required for each Size 50 horizontal Contactor and there is no structural steel requiring fireproofing. There are only two shafts to align instead of six. Piping is shortened and simplified by all being at low elevation. For units with mechanical refrigeration the suction traps are mounted above and supported on the Contactor shells. No refrigerant pump is required since thermo-syphon flow can be established in the U-tube type bundle when it is in horizontal position. There is even the possibility of eliminating the acid circulating pumps by elevating the acid settler and introducing the acid return line from the settler at the suction side of the Contactor impeller. The total of all these savings in equipment, erection time, and erection costs not only represents a considerable sum of money but it also means a considerable saving in tonnage of steel required at a time when steel conservation is necessary.

Sulfuric Acid Alkylation

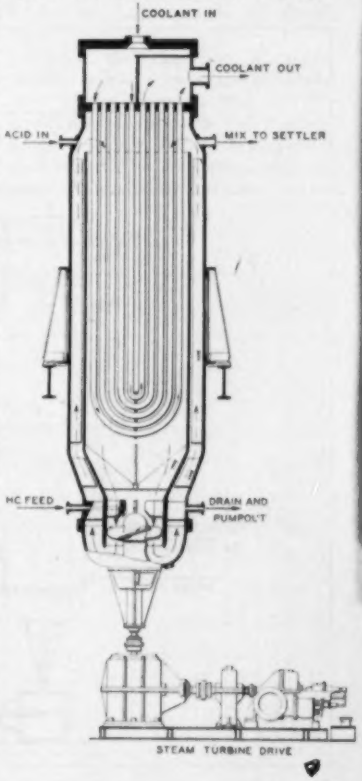
Improvements In Existing Plants

There were 64 alkylation Contactor reactors built for sulfuric acid catalyst during World War II, most of which are now in operation. All of these are of the general type shown in Figure 3. It is necessary when employing sulfuric acid as the catalyst that operating reaction temperatures be held in the range of 40° to 60° and therefore all such units are refrigerated. Some use ammonia as the refrigerant, a considerable number use propane and a few use isobutane.

The Contactors in all of these units were originally of the type shown in Figure 1, although some of them are now being modernized with new high capacity tube bundles as illustrated in Figure 4 and with refrigerant pumps installed as shown in Figure 5. The U-tube bundle for sulfuric acid Contactor reactors is the same as described previously for hydrofluoric acid service. It will provide 2½ times the heat removing capacity of the original extended surface tube bundle for the same MTD or will take care of the same heat removal for only 40 percent as much MTD as the original tube bundle. This makes possible a higher suction pressure to the refrigerant compressors and an increased capacity of existing refrigeration units, provided auxiliary equipment is of ample size.

Some of the existing sulfuric acid alkylation units which include more than one Contactor are operating with all Contactors discharging acid-hydrocarbon mix into one common settler and recycling acid from this settler to each of the contactors. The acid strength in all Contactor reactors is thus at the same level. Such an operation can be improved by the installation of an additional settler or settlers or by the division of the existing settler into separate settling zones so that the acid strength can be carried at a different level in each settler. For example, take the case of a plant in which two Contactors are operating with a single settler on butene alkylation, where fresh acid is fed at 98 percent strength, where the recycle acid is carried at 90 percent strength and where the rerun yield of 280° F end point aviation alkylate is 93.3 percent of 93.0 ASTM octane. If separate settling zones are provided for the effluent mix from each Contactor and the recycle acid from each settling zone is returned to the Contactor from which it came, then the acid strength in each of these two Contactor-settler systems can be carried at a different level. In the first zone the acid can be fed at 98 percent H_2SO_4 and maintained at a level of, say, 94 percent H_2SO_4. The spent acid from this first Contactor-settler system at 94 percent strength becomes the feed to the second Contactor-settler system where it is spent down to 90 percent H_2SO_4

Figure 4. Vertical Contactor, U-Tube Bundle.



and then discarded from the plant. Both Contactors are operated in parallel on both butane-butene feed and recycle isobutane. The alkylate which is made in the system operating at the 90 percent H_2SO_4 level will be the same in both yield and octane as it has previously been, but that half of the alkylate made in the system operated at the 94 percent H_2SO_4 level will show an increase in rerun yield of approximately 3.2 percent and an increase in ASTM clear octane of about 1.2 points. With three or more Contactors, each with separate settling zone, the overall improvement is even greater. The curves shown in Figure 7 show the effect of recycle acid strength on ASTM octane and rerun yield of 280° F. endpoint aviation fraction from a typical case of butene alkylation with all other operating conditions remaining constant.

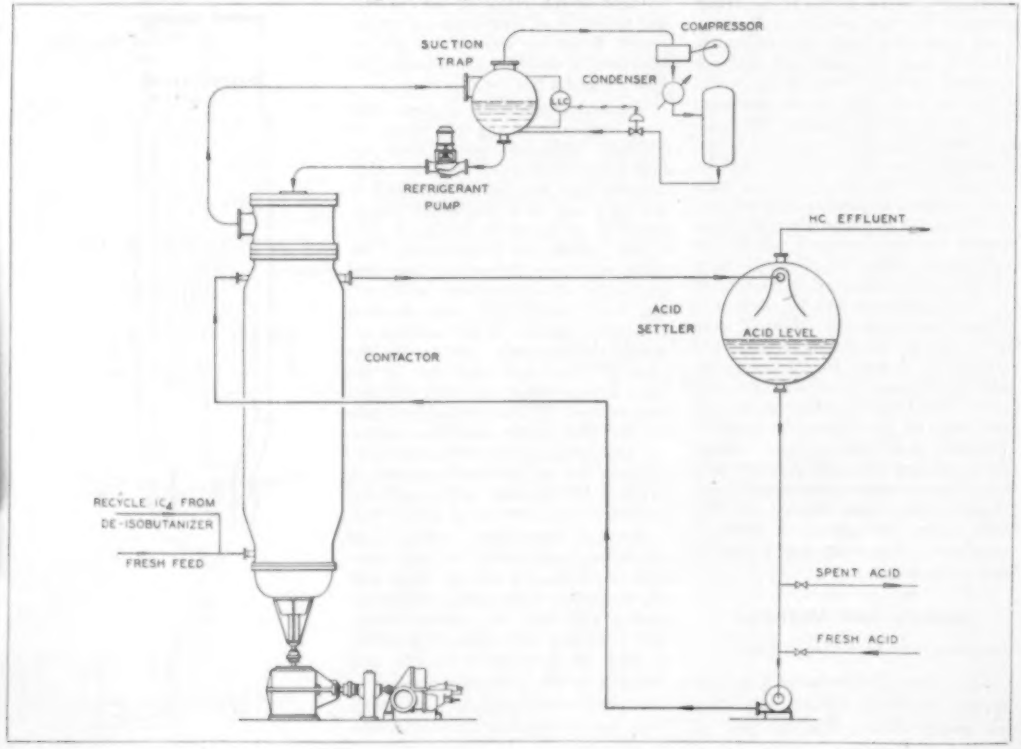
New Sulfuric Acid Alkylation Reactor Systems

The latest design of Contactor-reactor for sulfuric acid alkylation plants is as shown in Figure 6 with bare U-tube bundle and with acid inlet at the suction side of the impeller. For an installation requiring only a single Contactor it is connected to auxiliary equipment as shown in Figure 8. For installations large enough to warrant more than one Contactor each Contactor is provided with its own settler in order to take advantage of multi-stage acid operation as described in the preceding paragraph.

Such a unit offers a number of economies as compared to the original vertical type unit. As noted previously under the description of the latest type HF units these horizontal Contactors require no steel supporting structures. The drive is by means of a direct connected explosion proof motor with all driving gears eliminated. The suction trap is supported on the contactor shell by means of saddles. Connecting pipe lines are shorter and the piping is simplified by being closer to ground level and by the elimination of the acid recycle pumps. By elevating the acid settler a few feet the recycle acid is returned from the settler to the Contactor without the use of a pump. The differential pressure across the Contactor impeller runs about 5 psi. The mix outlet from the Contactor is taken from the discharge side of the impeller on the upstream side of the Contactor tube bundle. By returning the recycle acid from the settler to a point on the down-stream side of the Contactor tube bundle at the suction side of the impeller, a major portion of this five pounds differential is available for taking care of the pressure drop across the recycle acid control valve and friction loss in the line. Moreover, with the settler elevated additional pressure is available by reason of the difference in gravity between the HC-acid mix in the line to the settler and the recycle acid only in the acid return line.

A unit of this type for alkylating propylene or mixed feeds is ordinarily installed and operated without the dotted lines shown in Figure 8. The refrigeration cycle is operated as a closed system, heat being removed indirectly from the reaction zone by exchange through the Contactor tube bundle. Change in composition of the feed stock does not affect the refrigeration cycle and no isobutane is evaporated from the reaction zone as in the case of units cooled by self-evaporative refrigeration. Such a system can handle a great variety of feed stocks including propylene and the usually attendant

Figure 5. Refrigerated Unit, U-Tube Bundle.



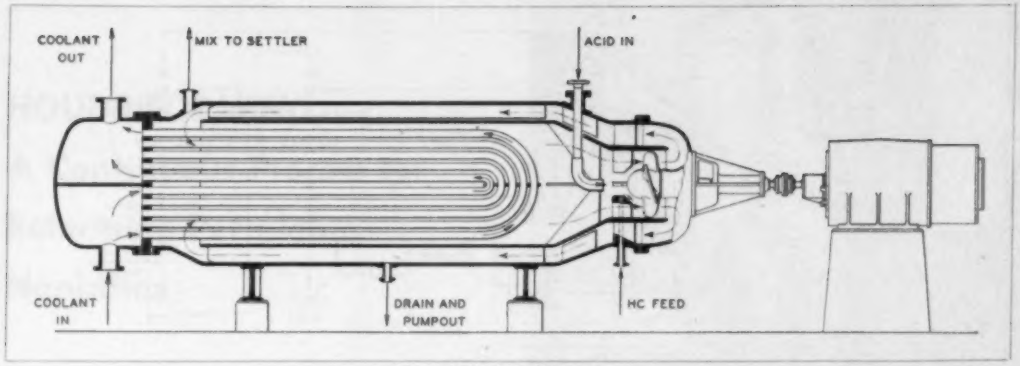


Figure 6. Horizontal Contactor.

appreciable quantities of propane without disadvantageously upsetting the operation of the refrigeration cycle.

A recommended method for installing new reactor systems is to incorporate the bypass lines indicated by dotted lines in Figure 8 and containing valves lettered A, B and C. The refrigeration compressors are designed and rated for using isobutane as the refrigerant. When the olefin feed contains appreciable quantity of propane or a high percentage of normal butane then the refrigeration system is operated as a closed system on isobutane, valves A, B and C being closed, and valves D and E being open. When the unit is to operate on a feed stock containing low percentages of propane or other diluent then valves A, B and C are opened while valves D and E are closed. In this way all the hydrocarbon effluent from the settler is passed through the suction trap, is chilled by the evaporation of isobutane therefrom and used as the cooling medium in the Contactor tube bundle. The liquid effluent from the suction trap becomes the feed to the deisobutanizer tower which then operates at greatly reduced overhead load. The isobutane evaporated in the suction trap and in the tube bundle is compressed, condensed, and returned to join the composite feed to the Contactor. Since all of the isobutane recycled in this manner passes completely through the reaction zone and settler it has the desirable effect of greatly increasing the external isobutane-olefin ratio which is recognized as of major importance in making for high yield and quality of alkylate as well as for low acid consumption. If, for example, with a feed stock as described, the isobutane recycled through fractionation makes for an isobutane: olefin ratio of only 3-to-1 and if the refrigeration compressor condensate is also recycled to the Contactor, the net result is a composite feed containing isobutane in amount of between 8 and 9 parts to each part olefin. None of this isobutane is evaporated from the reaction zone as in the case of self-refrigerated reactors, and it is therefore just as effective in promoting good alkylation conditions as it would be had it been recycled through fractionation at extra cost.

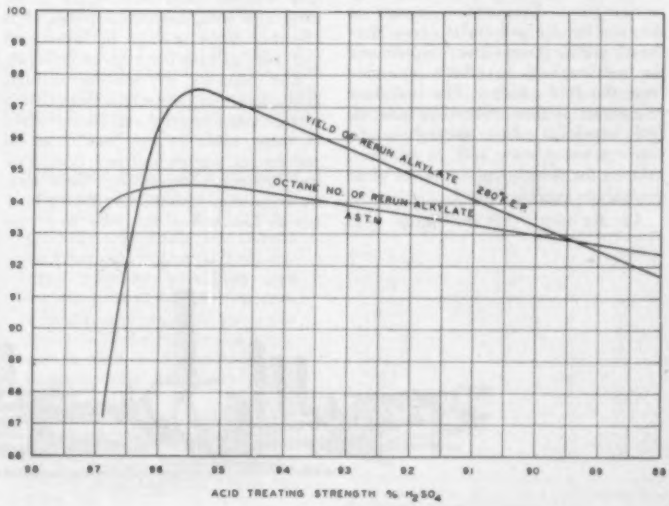
Possible Future Improvements In Sulfuric Acid Alkylation

During the past ten years considerable study and pilot plant work has been done on a two-stage alkylation process consisting fundamentally of a primary absorption stage wherein the olefins from a hydrocarbon mixture are absorbed in recycle alkylation acid, and a secondary alkylation stage wherein isobutane is alkylated by this olefin-acid mixture. There is no full scale commercial application of this process to date but it has three distinct advantages for future consideration.

First, it makes available for alkylation the large quantities of propylene (and some butenes) which are present in refinery tail gases. In most refineries these olefins are being burned with the tail gases because their concentration and recovery by conventional means would not be a profitable operation. When more alkylation feed stocks can be utilized the absorption of these olefins becomes economically attractive.

Second, the two-stage alkylation process makes it possible to eliminate most of the diluent normal paraffin hydrocarbons (propane and butane) from available liquid hydrocarbon feed stocks. The deleterious effect of these diluents in an alkylation system

Figure 7. Effect of Acid Strength on Yield and Octane.



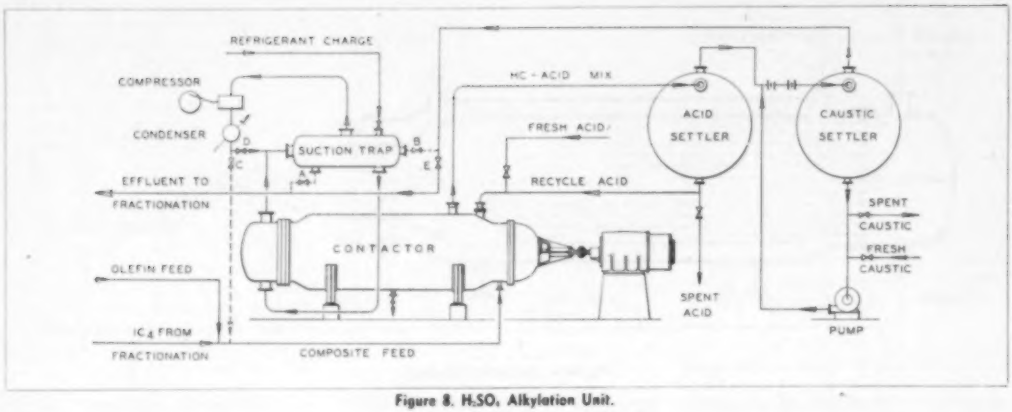


Figure 8. H_2SO_4 Alkylation Unit.

is well known and where alkylate quality must be improved the process provides a means for so doing by absorbing the olefins from the feed in recycle acid, passing the remaining normal and isoparaffins to fractionation, and alkylating isobutane with the olefin-acid mix from the absorber.

Third, with practically all propane and normal butane eliminated from the alkylation zone as described above the application of effluent refrigeration as shown by dotted lines in Figure 8 becomes very attractive. The vapors from the suction trap will be largely isobutane. When these are condensed and returned to the reactor feed the external isobutane:olefin ratio will be increased 5 to 7 points. It is unnecessary to take this refrigerant condensate through fractionation. All of it passes through the entire reaction zone and none is vaporized therefrom as in the case of units cooled by self-refrigeration. Evaporation occurs in the tube bundle and suction trap after the alkylation reaction is complete and the hydrocarbons have been separated from the acid catalyst. The isobutane refrigerant is then utilized to exert its full beneficial effect throughout the entire reaction zone and, in addition, relieves the deisobutanizer tower of an equivalent overhead load.

As the need for alkylation feed stocks increases, as need for higher alkylate quality arises, or as deisobutanizers become the bottleneck of existing plants this two-stage process should be investigated. All the operating conditions of absorber temperature, absorber residence time, acid: olefin ratios, etc. as required for high quality and yields have been well established by pilot plant operation and the process could be applied commercially with very little further investigative work.

Summary

The capacity of existing HF alkylation Contactors can be considerably increased by the installation of new type cooling elements with no increase in power requirements. New HF alkylation Contactors are rated up to the capacity of these new cooling elements and are installed in horizontal position without steel supporting structures and with simplified drives, thus effecting large savings in investment cost and utilities for a given capacity.

The capacity of existing sulfuric acid alkylation Contactors and existing refrigeration systems can be increased in many cases by the installation of refrigerant pumps and new type cooling elements. New sulfuric acid alkylation reactor systems, employing horizontal Contactors with the new type cooling elements are built with simplified drives and without steel supporting structure to effect economies of both material and investment cost. In some cases either new or existing units can utilize the principle of "effluent refrigeration" to greatly increase isobutane olefin ratios. Effluent refrigeration involves the use of the total hydrocarbon from the settler as the refrigerant to the cooling elements of the Contactor reactor and the evaporation of isobutane from this hydrocarbon effluent to effect the cooling in the reactor. The evaporated isobutane is condensed and recycled entirely through the reaction zone and settler before again being evaporated within the cooling elements of the Contactor.

The two-stage alkylation process wherein olefins are first absorbed in recycle acid prior to their introduction into the reaction zone offers possibilities for increasing the supply of available olefinic alkylation feed stocks and for improving the quality of alkylate made from existing feed stocks which contain large quantities of normal paraffins.

NOTE

Certain features of process and apparatus described and illustrated in this article are covered by patents issued and pending. Text or illustrations are not to be reproduced without permission of the Stratford Engineering Corporation.

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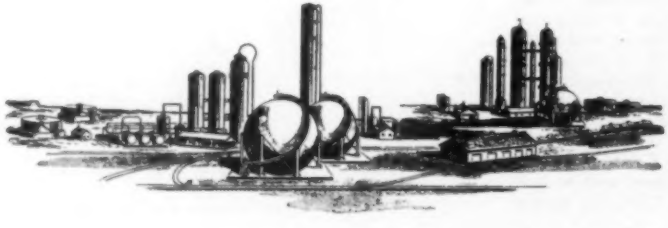


HOUDRIFORMING---
A Continuous Process for Reforming Petroleum Naphthas

C. G. KIRKBRIDE
Houdry Process Corporation
Marcus Hook, Pa.

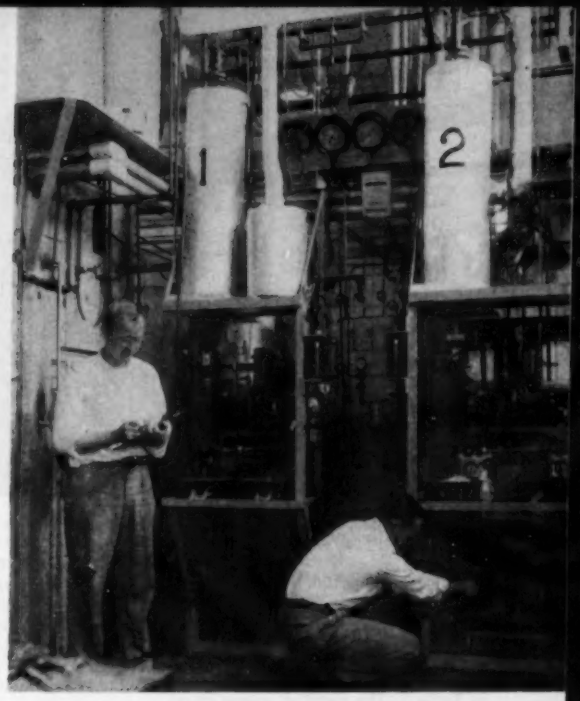


Figure 1. Isothermal Unit of Houdriforming Pilot Plant.

HOUDRIFORMING is a catalytic process for reforming petroleum naphthas to aromatic concentrates and high octane gasoline. Dual-function catalysts have been developed for this process. These catalysts are very selective for 1) the dehydrogenation of C_6 ring naphthenes, 2) the dehydro-isomerization of alkyl cyclopentanes, and 3) the isomerization of normal and slightly branched paraffins into highly branched paraffins. Essentially no hydrocracking occurs and, therefore, substantially pure hydrogen (97 per cent+) is produced. The catalysts are not affected by sulfur compounds including thiophene. The process is nonregenerative, although for flexibility of operation and for protection in case of error in operation the catalyst can be regenerated in place. The process is in an advanced state of pilot plant development. Detailed process design and mechanical engineering for commercial scale operation are underway.

The selective transformation of the constituents of naphthas without cracking has been the object of reforming for many years. Thermal reforming,[1] hydroforming,[2] and catalytic reforming processes employing platinum catalysts[3] have shown the trend for more specific reactions. In the experimental work to be presented, the effect of changing catalyst properties will be discussed.

Houdriforming is capable of the production of maximum yields of benzene, toluene, and xylene from specific fractions of a crude. Production of benzene and toluene will be discussed from an experimental and theoretical viewpoint. The production of high yields of high octane gasolines from straight-run naphthas by Houdriforming will then be discussed. The isomerization function of the catalyst in addition to the dehydrogenation function permits the reforming of low octane naphthas to high yields of product of very high octane number.

The Houdriforming process can be visualized by considering typical pilot plants in the Houdry Laboratory shown in Figures 1 and 2, and the simplified flow diagram, Figure 3. These pilot plants represent, respectively, "isothermal" and "multibed adiabatic" units.

HOUDRY Process Corporation recently announced a new continuous process for catalytically reforming low octane number naphthas to high octane number gasolines and for the production of benzene, toluene, and xylenes from petroleum. Catalyst for the process is said to be made from commercially available materials.

The article published here was first presented before a joint regional meeting of the AIChE and ACS in Tulsa on May 16, 1951.

In life tests (30-50 days of continuous operation without regeneration or loss of catalyst activity) in multibed adiabatic units, different charge stocks were processed at widely varying conditions over the same catalyst. A charge stock comprising a 150-220° F. cut of an East Texas type naphtha was used as a base stock and was run periodically at fixed conditions to check the catalyst activity. The properties and composition of this stock are presented in Table 1.

The availability of naphthenes in this charge stock would allow a stoichiometric yield of 48.4 volume per cent aromatics based on the charge; this includes the aromatics originally present in the charge. Stoichiometric

TABLE 1
Inspection of Base Charge Stock for Aromatic Production

Boiling Range*	150-220 °F.
Gravity, °API	60.2
Distillation, ASTM:	
IBP, °F.	162
10 Percent	180
30 Percent	185
50 Percent	190
70 Percent	196
90 Percent	204
Dry Point	215
Composition:	
Benzene	1.8
Toluene	4.2
Methyl Cyclopentane	5.1
Cyclohexane	14.3
Dimethyl Cyclopentanes	9.2
Methyl Cyclohexane	22.7
Paraffins	42.7

* Temperatures are the cut points during preparation of this stock using a 20 plate distillation column.

Figure 2. Multibed Adiabatic Unit, Houdriforming Pilot Plant.

conversion of the naphthenes, as will be evident later, is not directly attainable because of thermodynamic equilibrium considerations.

The yields of aromatics produced from this charge stock are summarized in Table 2. The yield of aromatics increases to very high levels as the severity of operating conditions is increased. A significant fact is that the hydrogen recycle gas and off gas from the unit consists of 97.5-98.5 volume per cent hydrogen at all conditions. In this operation gas separation was effected in a simple pressure separator at atmospheric temperature. The yield of hydrogen is better than 90 per cent of theoretical based on conversion of naphthenes to aromatics. These facts indicate that the catalyst is very selective and promotes very little hydrocracking at the operating conditions employed.

The base charge stock described previously was processed at a fixed set of conditions. Check runs were made with this stock at the same conditions after 18, 24, and 35 days of continuous operation. No change in the activity of the catalyst could be detected at any of these check intervals. For the investigation of process variables, a multibed adiabatic unit has been used.

TABLE 2
Houdriforming Operations Processing a 150-220° F. East Texas Type Naphtha for Benzene and Toluene Production

	ORDER OF INCREASING SEVERITY		
	1	2	3
Liquid Product C_6-Free, Vol. Percent of Charge	93.2	92.2	91.5
Aromatics in Liquid Product, Vol. Percent	38	45	48
Conversion of Naphthene to Aromatics, Percent	70	84	90
Unit Off Gas Produced, SCF per Bb	1160	1310	1360
Hydrogen Content of Off Gas, Vol. Percent	98.5	98	97.5

The same unit has been used to obtain engineering design data. Typical of the type of information obtained is the temperature pattern for the first reactor shown in Figure 4. Similar patterns prevail in succeeding reactors. However, the temperature drop decreases for each succeeding reactor as will be seen later. The number of reactors put in series is dependent on the particular stock to be processed and the type of operation to be carried out.

Other stocks investigated have included C_6 fractions containing up to 57 percent methyl cyclopentane. In addition to quantitative dehydrogenation of cyclohexane present, major proportions of the methyl cyclopentane have been converted to benzene, depending on severity of operations and nature of feed.

Theoretical

Thermodynamic considerations are significant in aromatics production because they limit the products which can be attained under the various operating conditions.

Consider the two reactions involved in benzene formation:

(1) C_6H_{12} (cyclohexane) $\rightleftharpoons C_6H_6 + 3\ H_2$;

$$Kp^{(1)} = \frac{(PH_2)^3\ (pC_6H_6)}{(pC_6H_{12})} = 10^6 \text{ at } 950°\text{ F.}$$

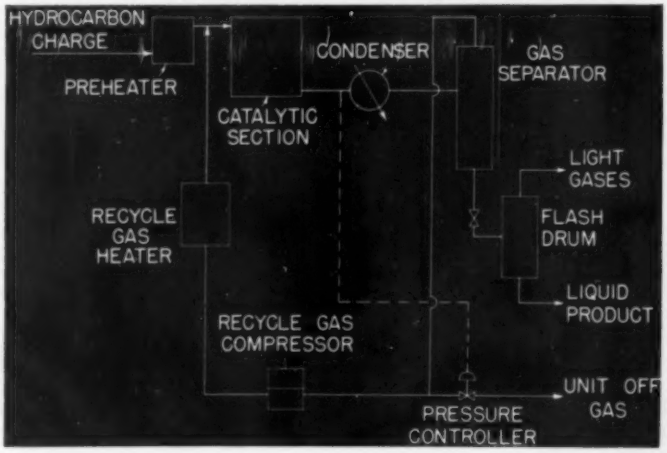
(2) C_6H_{12} (cyclohexane $\rightleftharpoons C_6H_{12}$ (methyl cyclopentane);

$$Kp^{(2)} = \frac{P \text{ methyl cyclopentane}}{P \text{cyclohexane}} = 12 \text{ at } 950°\text{ F.}$$

The *pressure* of hydrogen obviously has a very powerful influence on the C_6H_6 to C_6H_{12} mole ratio in the product and indeed, in the pressure range studied, is the limiting factor for benzene production at a given temperature. It is evident from Figure 5 that at pressures above 300 psi. the equilibrium amount of benzene falls off rapidly, while the amounts of cyclohexane and cyclopentanes concomitantly increase. On the other hand, the equilibrium toluene concentration remains high to a much higher pressure than for benzene. Figure 5 is based on thermodynamic data from API Project 44[4] and represents the equilibrium condition for an East Texas type naphtha at a H_2/oil mole ratio of 4 at 950° F., olefin formation not being permitted. Under the present circumstances, pressures may be substituted for fugacities satisfactorily.

Temperature affects the several equilibria to a critical degree. This is shown by Figure 6 in which is presented (for a H_2/hydrocarbon mole ratio of 5 and a total pressure of 300 psi.) the relative amounts of benzene-cyclohexane and benzene-cyclohexane-methyl cyclopentane. It is evident that isomerization to form methyl cyclo-

Figure 3. Simple Flow Chart of Houdriforming Process.



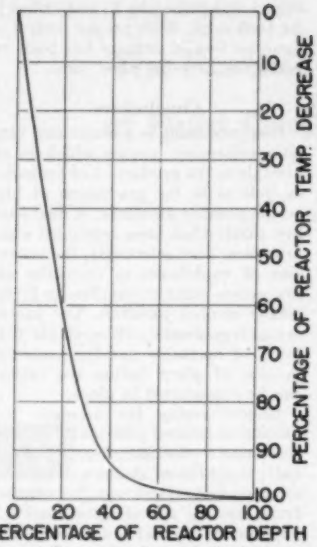


Figure 4. Temperature Pattern in Houdriforming Reactor.

pentane offers an important reaction from the standpoint of benzene yield.

Of course it should be realized that if a stock to be processed contains a large percentage of cyclohexane it would be better to employ a catalyst not having isomerization activity. However, most commercial light naphthas contain relatively important quantities of methyl cyclopentane; hence it is necessary to employ a catalyst possessing dehydroisomerization activity.

The maximum yields obtainable in adiabatic operation can be calculated on the basis of thermodynamic equilibrium, the heat of reaction, and the heat capacity of the reaction constituents. Dehydrogenation of naphthenes is highly endothermic and this heat is supplied by the sensible heat of the reaction constituents. A temperature-conversion line can be calculated, starting at reactor inlet conditions of temperature and composition. When plotted on the same figure as the equilibrium composition, this line will intersect the equilibrium line at a point which then represents the maximum amount of aromatics obtainable in a single adiabatic reactor. This is shown in Figure 6 for cyclohexane dehydrogenation with a reactor inlet temperature of 925° F.

In actual operation, dehydrogenation and isomerization reactions of all the naphthenes to respective aromatics must be considered. Heat carried by paraffins is substantial. The adiabatic operating lines and thermodynamic equilibrium for the stock, specifications of which are given in Table 1, are shown in Figure 7. The effect of reactor inlet temperature and number of reactors is clearly illustrated. It was found experimentally that individual reactor operation of Houdriforming followed closely the theoretical adiabatic operating lines.

Ordinarily the process is non-regenerative for the production of aromatics from a single wide cut charge stock. However, for most severe conditions on unusually wide boiling range charge, a catalyst deposit may accumulate slowly and the ability of the catalyst to be regenerated provides maximum flexibility. Thus a non-blocked out operation can be employed for the simultaneous production of benzene, toluene, and xylenes.

Upgrading of motor gasoline by Houdriforming is accomplished by five reactions: conversion of six-membered ring naphthenes to aromatics, dehydro-isomerization of alkyl cyclopentanes to aromatics, isomerization of straight chain or slightly branched paraffins to highly branched paraffins, dehydrocyclization of paraffins to aromatics and desulfurization of naphtha which improves the lead response. The isomerization function of the catalyst for converting low octane paraffins to high octane branched chain paraffins is of great importance in attaining the high yield of high octane reformate.

Conversion of naphthenes to aromatics improves the octane rating only in the case of higher boiling naphthenes. Thus, the conversion of methyl cyclopentane and cyclohexane (F-1 blending value 107 and 110, resp.) to benzene (F-1 blending value 99) actually involved a loss of blending number octane, while the conversion of dimethyl cyclohexane to xylene increases the blending octane number

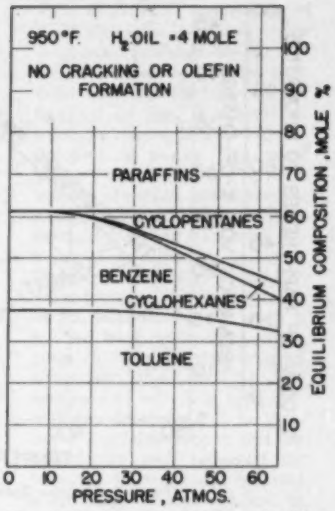
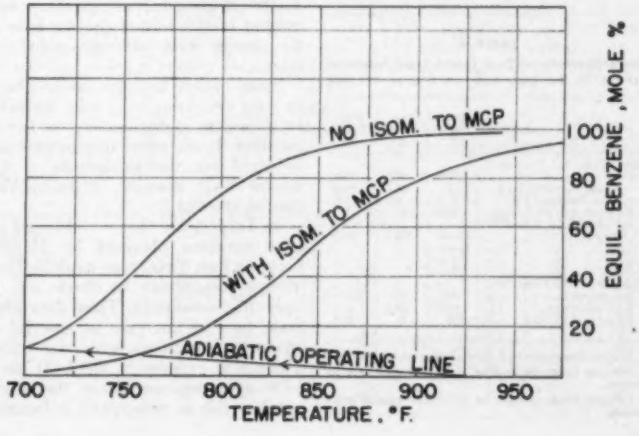


Figure 5. Equilibrium for East Texas Naphtha.

from 68 to 145. In employing Houdriforming for motor gasoline production it is, therefore, desirable to use only feed stocks which have been fractionated to include the maximum amount of naphthenes in a boiling range in which octane improvements can be obtained.

In Figure 8 are shown octane-yield relationships for an East Texas type naphtha after Houdriforming under different operating conditions with different catalysts. The specifications of this naphtha are given in Table 3. Curve A, Figure 8, represents results obtained with a commercial molybdena-alumina hydroforming catalyst and shows how hydrocracking lowers yield without corresponding octane gain. Also a type of hydrocracking occurs with this catalyst which causes

Figure 6. Dehydrogenation of Cyclohexane.



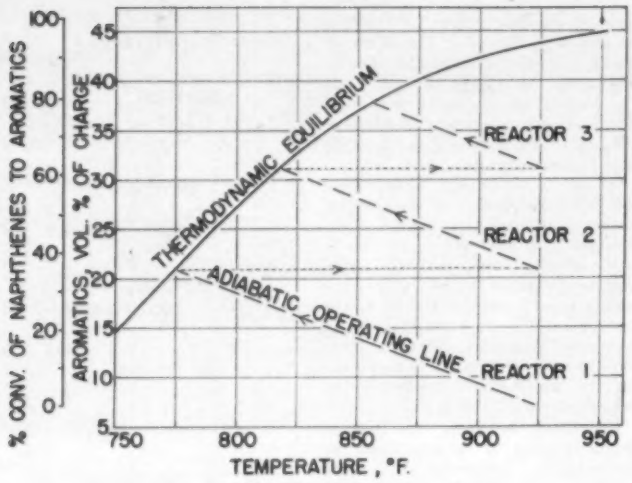


Figure 7. Adiabatic Operation of Houdriforming Unit.

catalyst deposit formation requiring frequent regeneration. Curves B and C were obtained with different Houdriforming catalysts; B has only a dehydrogenation function whereas C has both dehydrogenation and isomerization functions. The differences between these catalysts become most apparent at high octane numbers. It is quite striking also that a 78 volume percent yield of C_{5+} 3 lb. RVP product of 97.3 F-1 clear octane number was obtained with catalyst C.

TABLE 3

Inspection of Charge Stock for Gasoline Production

(East Texas Type Naphtha)

Boiling Range	188-368 °F.
Gravity, °API	55.3
Distillation, ASTM:	
IBP, °F.	188
10 Percent	215
30 Percent	232
50 Percent	252
70 Percent	280
90 Percent	317
Dry Point	349
Sulfur, Percent	0.006
Composition:	
Paraffins, Vol. Percent	44
Olefins, Vol. Percent	0
Naphthenes, Vol. Percent	42
Aromatics, Vol. Percent	14
Octane Number: F-1 Clear	51.2
F-1+3 cc. TEL	76.6

TABLE 4

Houdriforming of East Texas Type Naphtha

188-368° F., F-1 Clear 51.2, F-1 + 3 cc. TEL 76.6

	Condition I	Condition II	Condition III
Yield, C_{5+}, Vol. Percent of Feed	77.7	88.5	96.0
Weight Percent of Feed	82.8	92.7	98.0
C_4, Vol. Percent of Feed	17.2	6.1	1.2
F-1 Clear, 3 lb. RVP Gaso.	97.3	91	71
F-1+3 cc. TEL, 3 lb. RVP Gaso.		98	87
	Iso-octane+ 0.3 cc TEL		
Yield, 10 lb. RVP Gaso. Calc., Vol. Percent	95*	98†	106‡
F-1 Clear, Calc.	98	92.5	75
F-1+3 cc. TEL, Calc.	>100	99	80.5

* Excess butane over 10 lb. RVP gasoline is 8.9 vol. percent.

† Outside butane required for 10 lb. RVP gasoline is 3.4 percent.

‡ Outside butane required for 10 lb. RVP gasoline is 8.8 percent.

All yields and octane numbers in Figure 8 are for C_4-free gasoline of about 3 pounds RVP. Considerable outside butane may be added to bring the gasoline to 10 pounds RVP. Overall yield and, to a certain extent, also octane numbers are thereby raised. Catalyst C under proper conditions can produce enough butane to obtain 10-pound RVP gasoline. However, catalyst B under all operating conditions and catalyst C under mild conditions give products to which outside butane must be added. Butane produced in Houdriforming and the outside butane required thus compensate for most or all of the volume loss suffered in converting the naphthenes to aromatics. Indeed, as shown in Table 4, the 10-pound RVP gasoline may amount to 100 volume percent plus of the charge when utilizing added butane.

Since outside butanes are available in most refineries, it is very desirable to eliminate hydrocracking as far as possible. In the event that butanes are required for the production of 10-pound RVP gasoline, hydrocracking can be effected.

In Table 4 are shown yields and octane numbers obtained by Houdriforming East Texas type naphtha (previously described) at three sets of operating conditions. These data illustrate how an increase in severity of operating conditions will raise octane number at expense of yield. At desirable operating conditions the usable catalyst life is principally a function of external poisoning by impurities in the feed stock. With proper control of these no loss in activity has been experienced in pilot plant runs.

Conclusions

Houdriforming is a continuous catalytic reforming process which is applicable to the production of aromatics as well as to the production of high octane number gasolines. A dual-function catalyst has been developed which promotes, very selectively, the conversion of naphthenes to aromatics and low octane number paraffins to higher octane number paraffins. The process is non-regenerative, although for flexibility of operation and for protection in case of plant failure the catalyst can be regenerated in place.

Houdriforming for aromatic production is limited principally by thermodynamic considerations. Substantially equilibrium amounts of benzene, toluene, and xylene can be obtained from the five and six-membered ring naphthenes contained in naphtha stocks.

ACKNOWLEDGMENT

The development of the Houdriforming catalysts is a result of the fundamental research which Houdry Process Corporation has carried on for a number of years. Heinz Heinemann, T. H. Milliken, G. A. Mills, and A. G. Oblad are primarily responsible for the success of this program.

It is appropriate that credit be given to J. C. Dart, J. W. Schall, T. A. Burtis, and D. H. Stevenson for the successful pilot plant development of the Houdriforming process.

The contributions of other members of the staff are also acknowledged.

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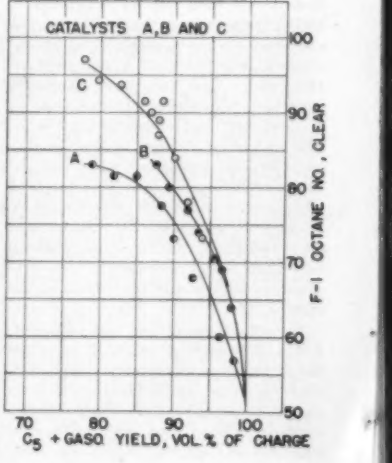
Figure 8. Houdriforming of 180°-370° F. East Texas Naphtha.



IMPROVED METHODS FOR—

The Particle Size Analysis of Fluid Cracking Catalysts

Part 1

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THE EFFICIENT operation of fluid catalytic cracking units is greatly assisted by an accurate knowledge of the particle size distribution of the catalyst in use. A variety of analysis means have been developed to serve this need within our industry and a variety of results are presently being obtained. The analysis method reported here was developed specifically to serve the requirements of a catalyst manufacturer. In the opinion of the manufacturer's staff, it is "the best method we have seen to date for determining accurately the particle size analysis of our fluid type petroleum catalysts." It is their hope that this report will be sufficiently well received by industry to warrant general adaptation of this method of particle size analysis.

The report will be published in three parts. Parts II and III will appear in the succeeding issues of Petroleum Refiner.

WITHIN the last decade, the process industry has witnessed the advent of a new technique generally identified as the fluidized solids system. Up to the present time, the principal commercial application of this technique is found in the modern petroleum refinery in the form of Fluid catalytic cracking process. Herein a powdered catalyst, the great percentage of which is comprised of particles smaller than 100 microns, is maintained in a condition of admixture with various gases such that the resultant mass possesses many of the physical characteristics of a true fluid. The particle size distribution of this or any powder plays a predominant role in fixing its physical properties in the fluidized state. As a result the need has become increasingly pressing, particularly within the petroleum and fluid catalyst manufacturing industries, for analytical methods which will provide particle size distribution data characterized by both high accuracy and precision. While valuable work has already been reported, existing methods fall short of satisfying either one or both of these criteria. Accordingly, it has been our purpose to develop test methods which will provide results with a high degree of precision and which are mutually comparable regardless of the type of catalyst analyzed.

In this article the methods of necessary sample preparation are discussed, and the statistical methods by which the various tests were designed and the data analyzed are described. The reasons which led to the acceptance of screening and air elutriation as the basic means for testing are given. The four variables of significance in screening are size of sample, time of shaking, moisture preconditioning of the sample, and physical variation in and between the screens. A test procedure was developed which comprises a two-hour sample humidification using air of 60 percent relative humidity followed by the 30-minute shaking of a 25 gram sample.

Definitions

Payne[1] has pointed out that the difficulty in measuring the particle size distribution of fine powders has arisen as much from the inability to clearly define the terms "particle" and "particle size" as from the actual problems involved in equipment design and laboratory technique. Specifically, the particles comprising Fluid cracking catalysts have a tendency to exist as agglomerates, either because of a slight fusion occurring during manufacture or because of electrostatic charges generated through handling. Therefore, unless a reproducible deagglomerating technique is included and unless a clear concept is defined as to what shall constitute a discrete particle, the term "particle" is ambiguous. Similarly, most Fluid cracking catalyst particles are irregular in shape, making it practically impossible to define "particle size" by any single parameter such as a measured dimension. Again, the term becomes ambiguous unless an empirical definition is established which is readily obtainable from the general method of analysis employed.

As hereafter employed, the term "particle" shall mean a single macroscopic piece of the catalyst material as distinguished from the "bunch of grapes" type cluster indicative of the agglomerate. The particle size is defined as the diameter of that equivalent perfect sphere which will exhibit the same behavior in a fixed air elutriation system. The diameter thus obtained is usually referred to as a "Stokes Diameter." The manner in which these definitions have been developed will become apparent later.

"Accuracy" can be defined as the ability to determine a true or consistent base magnitude independently of the precision associated with a single measurement. In contrast, "pre-

TABLE 1
Effect of Sample Size and Shaking Time in Screen Analysis

TEST CONDITIONS: Sample Size: Grams / Time: Minutes	25 / 30		50 / 30		25 / 10		50 / 10	
Screen Size: U. S. Mesh	On 140	T 200	On 100	T 200	On 100	T 200	On 100	T 200
Sample No.								
439	11.9	48.0	12.5	47.6	13.4	46.6	13.1	48.7
480	8.5	54.0	9.3	53.3	10.9	49.4	9.9	52.4
481	9.4	51.6	9.7	50.6	9.9	49.8	10.7	47.2
483	9.5	51.3	9.9	46.1	10.2	49.8	10.7	45.4
484	8.6	54.1	9.9	47.4	10.2	50.2	10.3	52.0
493	8.6	58.1	9.2	53.5	9.1	55.3	10.1	55.8
499	10.6	51.0	11.1	50.1	11.1	49.8	12.4	48.6
503	7.8	58.5	7.7	58.3	8.2	57.4	8.9	56.3
504	10.2	53.0	9.6	52.8	10.6	52.9	9.4	52.8
507	10.5	52.1	9.5	53.3	11.4	50.3	11.8	50.4
526	10.1	50.5	10.9	48.5	11.8	46.6	12.1	42.5
530	9.9	46.8	9.5	53.1	9.8	52.7	10.5	49.4
533	11.4	50.1	10.5	49.7	11.0	49.9	11.1	49.8

cision" is the ability to consistently reproduce a specific value irrespective of whether or not the magnitude is correct, and perforce carries with it the inference that the values will be distributed within definable limits. These limits, known as "tolerance limits," are mathematically defined as a function of the standard (root mean square) deviation of the data around its arithmetic average. For this work, 95 percent limits were set as an acceptance standard, and are calculated using twice the standard deviation. Here are followed the quality control nomenclature and usage rather than the more rigorous method of using the "t" distribution. Thus, when it is stated that the precision of a given measurement is "±a" units, it can be expected that 95 out of every 100 measurements of the value will fall within "±a" of the average and that the greater concentration of the measurements will lie around the average.

The Problem

The object of this work follows:

1) Having had general indications of the lack of precision and accuracy of the screen and Roller tests, to place quantitative values on these poor properties by statistically designed and controlled experiments.

2) To examine the field of existing test methods to ascertain whether methods other than the screen and Roller tests present greater hope of fulfilling the needs.

3) To develop necessary improvements in the methods finally chosen to achieve the end of satisfactory precision and accuracy; then to quantitatively evaluate the improved tests and compare them with the original methods by statistically designed and controlled experiments.

The importance of statistical evaluation in the program cannot be overemphasized. Experience has shown that experimental design and data evaluation carried on without the aid of mathematically rigorous statistical methods are invariably influenced by the element of human preference, and that this preference often creates a bias toward the direction which is most favorable. The application of expert statistical methods to this work assures a rigorous, unbiased appraisal. However, lest there be confusion on this point, the application of statistics does not lead to the development of a method per se. It provides the best tool for evaluating what is already developed.

Sample Preparation and Treatment of Data

Since statistical experiments of this type require that many samples of the same material be available for a multiplicity of duplicate laboratory analyses, the method of sample preparation is extremely critical. Any such method must insure that all of the small samples drawn have the same particle size distribution unaltered by the sampling procedure, and that the particle size distribution of the main mass of the material being sampled likewise remains unaltered. In the case of Fluid cracking catalysts this is no simple problem, since a tendency toward segregation is always existent. Here is the sampling technique consistently employed in our laboratory:

1) About 250 pounds of the material to be used as a standard are drawn into a fiber drum filled to no more than ¾ full. The drum is then sealed, laid on its side and rolled for a minimum of five minutes, reversing direction every ten feet of travel.

2) The drum is upended and five one-quart samples are withdrawn in rapid succession by total immersion in the aerated catalyst.

3) The drum is resealed and the entire process repeated. No more than five one-quart samples are ever withdrawn after one rolling.

4) The sample preparation is continued until the drum is only ¼ full, when sampling from the drum is ended. The residue in several drums is combined in one which is then treated in like manner.

5) When the quart sample is submitted to the laboratory for analysis, the jar is rolled to aerate the catalyst and sampling is accomplished with a thief which samples the entire contents from top to bottom. For extremely precise samples from a single jar, a closed Jones splitter is employed.

The precision and level of this or any test in our laboratory is determined by a statistically designed and controlled system of sample submission and data analysis. Samples of a catalyst standard prepared as described above are submitted to the laboratory by a Quality Control Group at frequent intervals using codification which confuses its true identity as a standard. Thus the sample is assured strictly routine handling without bias. These data are accumulated and analyzed by statistical methods to determine the average level and the 95 percent tolerance limits. By submission of the same jar at two separate times, it is possible to evaluate the variability of the laboratory either inclusive or exclusive of any variability which might be introduced by the sample preparation. Note that only by such statistical methods is it possible to estimate precision and simultaneously to state the actual confidence which can be placed in the estimation.

It has become apparent that, because of the wide range in particle diameter of the catalysts concerned, no single satisfactory test could be expected to suffice. Therefore in our laboratories as in others, screening has been used to determine the coarse fractions, while determination of the finer components has been carried out on a routine basis by two ramifications of the Roller test.[2, 3, 4] In addition, exploratory work has been conducted on two sedimentation methods for the finer fractions: modifications of (a.) the Andreason pipette[5] and (b.) the Oden sedimentation balance.[6]

The Screen Analysis

Our screen analysis has paralleled generally accepted methods. A weighed quantity of catalyst is placed in the top sieve of a nest consisting of six sieves sized U. S. 40, 60, 80, 100, 140 and 200 from top to bottom. The nest is placed in a Ro-Tap machine and vibrated for a specified time, after which the fractions remaining on each sieve and in the pan are weighed and the fractional amounts corrected to 100 percent weight recovery assuming that all loss occurs in the initial charge. Four variables were found to be critical in this test: 1) weight of sample; 2) time of shaking; 3) moisture preconditioning of the sample; and 4) the sieves themselves.

The results of early work in our laboratory to investigate the effect of sample weight and time of shaking are presented in Table 1. Rational thinking indicates that the better test would be the one which yields the highest screen efficiency, and that this might be the test using the smaller sample and the longer shaking time. Accordingly, the data in Table 1 were statistically analyzed to determine the level and precision of each type test relative to the 25-gram, 30-minute test. Using the statistical methods for paired data, the findings are presented in Table 2. The data analysis was limited to the 100 and 200-mesh sieves, since these finer screens are more affected by changes in method than the coarser sizes. In summary, it is indicated that the precision is unaffected by either the change in sample size or shaking time. But while the change in sample size had no effect upon level (magnitude), the shaking time was found to have a significant effect and in the direction expected, i.e. reduced the "on 100" and increased the "through 200." The statistics also indicate that there is no interaction between the sample size and shaking time, that is to say the two variables are completely independent.

As a result of these findings, our laboratories standardized on a sample of 25 grams and a shaking time of 30 minutes. With this procedure, the precision of the method was determined by periodic submission of the Stand-

TABLE 2

Effect of Sample Size and Shaking Time in Screen Analysis

TEST CONDITIONS: Sample Size: Grams / Time: Minutes	25 / 30		50 / 30		25 / 10		50 / 10	
SCREEN SIZE: U. S. Mesh	On 100	T 200	On 100	T 200	On 100	T 200	On 100	T 200
STATISTICS:								
N = Number of groups of data	13	13	13	13	13	13	13	13
$\overline{X}$ = Arithmetic Average level	9.8	82.2	9.9	81.1	10.6	80.6	10.8	80.0
σ = Standard Deviation = $\sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N-1}}$	1.17	3.30	1.35	3.44	1.47	2.06	2.65	3.89
$\overline{X}_D$ = Arithmetic Average of Differences from Test 1	....	....	0.18	1.14	0.82	1.42	1.08	2.34
σ_D = Standard Deviation of Differences = $\sqrt{\frac{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}{N-1}}$	....	....	0.20	0.90	0.22	0.72	0.22	0.76
"t" Test (t = 2.18 with 95 Percent confidence) = $\left\lvert\frac{\overline{D}-0}{\sigma_{\overline{D}}}\right\rvert$	....	....	0.90	1.28	3.75	1.96	4.82	2.95
Degree of significance	....	....	N. S.	N. S.	H. S.	N. S.	H. S.	S
"F" Test (F = 4.16 with 98 Percent confidence) = $\frac{\sigma^2 \text{ Larger}}{\sigma^2 \text{ Smaller}}$	....	....	1.37	1.09	1.61	1.32	5.26	1.39
Degree of Significance	....	....	N. S.	N. S.	N. S.	N. S.	S	N. S.

NOTES: "t" Test judges whether the methods give results which are significantly different in magnitude.
"F" Test judges whether the methods give results which are subject to difference in variability.
N. S. = Not Significant S = Significant H. S. = Highly Significant D = Difference between observations $\overline{D}$ = Avge. Difference between observations
In the above calculations, σ is used in the sense of the "estimate of the universe standard deviation". This is generally called "s" in the statistical literature.

ard Sample, amounting to 48 submissions (analyzed in duplicate) in eight months. The results of this study are shown in Table A.

TABLE A

Screen Size: U.S.	On 100	On 140	On 200
$\overline{X}$ = Average	7.0	23.2	38.7
2σ = Precision with 95 percent tolerance	±1.75	±2.73	±2.80

Obviously, there was still much to be desired in the precision of data from the finer screens. In an attempt to accomplish further improvement, moisture pre-conditioning of the sample and variability of the screens themselves were investigated.

Many fine powders, among them cracking catalysts, possess the ability to readily acquire and hold a large electrostatic charge. In a screening operation, this electrostatic charge causes a tendency to foul the screen. Webb reports[6] that this electrostatic fouling can become so acute that a particle will not fall through an opening twice its diameter. Our original technique for eliminating this charge consisted in spreading the entire sample in an 18-inch x 24-inch enamelled pan so that the bed was from ⅛ to ¼-inch in depth. The catalyst was left thus exposed to air for two hours, then sampled and analyzed. It was found that this procedure lacked reproducibility inasmuch as it was completely dependent upon the chance relative humidity of the atmosphere, and the effectiveness of the spreading varied accordingly.

To humidify in a reproducible manner within a reasonable time, an aeration procedure using air of 60 percent relative humidity at a controlled rate was adopted. About 100 cubic centimeters of the sample is carefully measured into a 1¼-inch i.d. glass tube about three feet in length. At the bottom the tube is drawn down to ¼ inch diameter and a glass ball-type check valve placed over the opening to support the sample. A standard 9-inch diameter Roller cylinder is attached to the top of the cylinder to insure fines retention, and 60 percent R. H. air is passed through the tube at a rate calculated to give a superficial velocity of 0.3 feet per second. This velocity is sufficient to aerate but not fluidize the bed. Humidification is continued for two hours. To check the loss of fines from the knock-back cylinder, a tared and humidified paper thimble was fastened to the discharge of the cylinder and kept in place during the entire two hour period. The increase in weight was found to correspond to less than 0.1 percent of the sample charged to the tube.

To analyze the effect of the variability between different screens of the same nominal size, numerous duplicate samples of a nearly perfect microspherical catalyst were pre-humidified as described above and submitted to the laboratory for the routine screen analysis. Microspheres were used for this work to eliminate confounding of the data with the uncertainties introduced by irregularly shaped particles. Results are presented as Table 3. It is immediately evident that the analyses fall into groups of different levels as a function of the particular nest of screens used. Furthermore, all of the data fall properly within and around the precision limits normally ascribed to the laboratory. The conclusion must be drawn, then, that a good portion of the laboratory variability is due to periodic changes in the screens used.

TABLE 3

Effect of Change in Screens Upon Screen Analysis

Sample No.	Screen Nest No.	SCREEN ANALYSIS: Weight Percent					
		On 40 Mesh	On 60 Mesh	On 80 Mesh	On 100 Mesh	On 140 Mesh	On 200 Mesh
1.	1.	0.8	1.6	2.4	3.2	7.6	36.1
2.	1.	0.8	1.6	2.4	3.2	7.6	35.6
3.	1.	0.8	1.6	2.4	3.2	7.6	35.9
4.	1.	0.8	1.6	2.0	2.4	6.4	34.1
5.	1.	0.8	1.6	2.0	2.8	6.8	22.4
6.	1.	0.4	1.2	1.6	2.4	6.1	22.8
Average	..	0.7	1.6	2.1	2.9	7.0	34.5
7.	2.	0.4	1.2	1.6	2.4	6.5	19.2
8.	2.	0.4	0.8	1.2	2.0	6.5	17.5
9.	2.	0.4	0.8	1.2	1.6	6.1	18.0
Average	..	0.4	0.9	1.3	2.0	6.4	18.2
10.	3.	0.4	1.2	2.0	2.8	6.5	21.1
11.	3.	0.4	0.8	1.2	2.0	5.7	22.1
12.	3.	0.4	0.8	1.2	2.0	5.7	21.6
Average	..	0.4	0.9	1.5	2.3	6.0	21.6
13.	4.	0.4	0.8	1.2	1.6	6.5	23.2
14.	4.	0.4	0.8	1.2	1.6	6.1	24.2
Average	..	0.4	0.8	1.2	1.6	6.3	23.5
Over-all Range	..	....	....	....	±0.80	±0.95	±4.3
Laboratory precision	..	....	....	....	±1.75	±2.73	±2.80

(N = 48, 95 Percent Limits).

Note: Screen sizes are U. S. Bureau of Standard Numbers. Fourteen duplicate samples of a truly microspherical catalyst were analyzed.

This should not be surprising, since standard sieves as normally purchased[7] are made to U. S. Bureau of Standards specifications as shown in Table B.

TABLE B

U.S. Sieve No.	100	140	200
Nominal Opening: Millimeters	0.149	0.105	0.074
Inches	0.0059	0.0041	0.0029
Percent Variation in Average Opening	± 6	± 6	± 7
Percent Variation in Maximum Opening	+40	+40	+60
Percent of Openings Exceeding Nominal Opening by more than ½ of Variation of Max. Opening	5	5	5

To improve the precision of the screens themselves, special arrangements were made with the manufacturer to supply us with matched sieves in the 100 and 200-mesh sizes, since the foregoing data indicate that it is only in the screens finer than 80 mesh that the manufacturing variability is pronounced. A quantity of our standard sample was sent to the manufacturer for testing on his master set of average certified equivalent sieves. All 100 or 200-mesh sieves for our use were then tested on this same standard catalyst, and only those sieves which gave the same average level as the master screens were shipped to us. Thus the attempt was made to substitute a performance specification based on the type of material on which the screen is ultimately to be used for a calibration or measurement of the screen openings. Results are shown in Table 4. It is immediately apparent that the expected improvement in inter-screen variability was not realized. The changes in sieves were accomplished in most cases by violent shifts in level even though the precision on the individual screens was unusually good. In retrospect, there are two possible circumstances which would lead to the failure of such a procedure of screen selections:

1) In selecting screens for our use, the manufacturer made three analyses per sieve on which his decision to accept or reject was based. The analytical variability of his laboratory might be sufficiently large that three analyses are insufficient to approach the true level for each screen tested. If this is correct, then the act of testing and selecting would actually be reduced to useless motion unless the number of tests made on each screen were increased to give a closer approach to the true level.

2) The procedure by which the manufacturer withdrew the catalyst samples from the large batch of standard catalyst sent him might be such that all the samples which he used in selecting screens were not the same. If his analytical precision were high, this difference in samples would appear directly as a real difference between the screens chosen as being the same.

Although the results from this attack on the problem of screen variability are certainly not encouraging, the attempt to achieve satisfactory results along this line has not been abandoned. Joint investigation by the interested parties is now in progress to ascertain why this scheme failed and what can be done to solve the problem. In fairness, it should be emphasized that the present failure in no way represents a criticism of the manufacturer, since his screens all fall well within specifications. However, since it is our need to work to limits much narrower than screen specifications, it is hoped that this program of mutual investigation will result in a workable procedure.

Having established a rigorous procedure for the screen analysis, and having evaluated its precision, some indication of the accuracy of the test was desired. The problem here was to decide what best constitutes a true judge of the particle size distribution. It was reasoned that examination by microscopic particle count would be the best criterion available provided first, that the difficulties introduced by measuring irregularly shaped particles be eliminated by working with spheres, and second, that the count be conducted by the best known methods designed to eliminate human bias. Accordingly, a large sample of a catalyst having truly microspherical particles was specially prepared, and small samples of this material broken out by the technique mentioned heretofore. It is emphasized that the material used for this work was a highly active catalyst with the same chemical and physical properties typical of commercially available catalysts, the sole difference being that the particles were truly spherical. Multiple screen analyses were then made to precisely establish the 100 and 200-mesh levels, and three samples were broken down into four cuts using a fritted disc non-attrition air elutriation procedure hereinafter described. These 12 cuts were submitted to a professional microscopist for determination of particle size distribution.

A few pertinent details of the manner in which the microscopist conducted his work are worthy of mention. From each of the 12 samples submitted, microscopic slides were prepared by multiple sample size reduction using an Otto microsplitter, a variation of the larger Jones splitter. The particles on the slide were dispersed with a light oil, and a cover plate mounted to eliminate particle movement. Traverses across the optical field were established using a lined optic, and the diameter of every particle lying on the traverse was measured using a micrometer eyepiece calibrated against a linear standard. Traverses were spaced to proceed across the field, and a total of about 300 particles were counted on each slide. One hundred and thirty-five diameter magnification was used on all fractions. Knowing the weight percent of total sample which each of the four component fractions represented, and assuming constant density over the particle size range, it was possible to calculate the particle size-weight distribution for the total sample. Thus three microscopic analyses on duplicate samples were available, each representing a count of about 1200 particles. Some idea of the amount of work involved can be gained from the fact that eight hours were required to prepare and count each of the 12 slides. However, it is believed that only by such painstaking, tedious work can a microscopic examination of any significance be made.

The results of the screen analyses and microscopic examinations are presented graphically in Figure 1. Several observations are of immediate importance. The reproducibility of the microscopic sample preparation plus counting is shown by the degree of coincidence of the three curves. As would be expected, the variance is larger in the middle sizes where the greatest concentration occurs. The

TABLE 4
Effect of Matched Sieves in Screen Analysis

Screen Set No.	1		3		4		5	
Mesh Size (U. S.)	On 100	On 200	On 100	On 200	On 100	On 200	On 100	On 200
	9.5	56.9	10.3	57.3	9.8	54.5	11.5	58.9
	9.5	57.1	10.7	56.3	9.9	56.0	10.5	57.2
	8.6	56.3	9.5	54.9	10.0	54.8	10.8	57.4
	10.2	58.2	9.6	55.8	9.1	56.0	9.0	55.7
	9.9	57.4	10.0	55.8	10.4	55.0	10.7	57.1
	10.0	58.2	9.9	54.8	9.9	54.8	10.6	57.9
	9.2	56.6	9.6	55.6	.....	.....	10.7	57.9
	10.0	57.4	10.2	56.1	.....	.....	.....	.....
	9.2	56.8	10.3	56.0	.....	.....	.....	.....
	10.7	58.1	9.6	55.2	.....	.....	.....	.....
	10.7	59.3	10.0	54.8	.....	.....	.....	.....
	.....	.....	9.9	54.6	.....	.....	.....	.....
	.....	.....	9.6	55.0	.....	.....	.....	.....
Average	9.8	57.5	9.9	55.6	9.8	55.2	10.5	57.4

NOTE: All analysis made on standard catalyst B-6. Samples were not prehumidified.

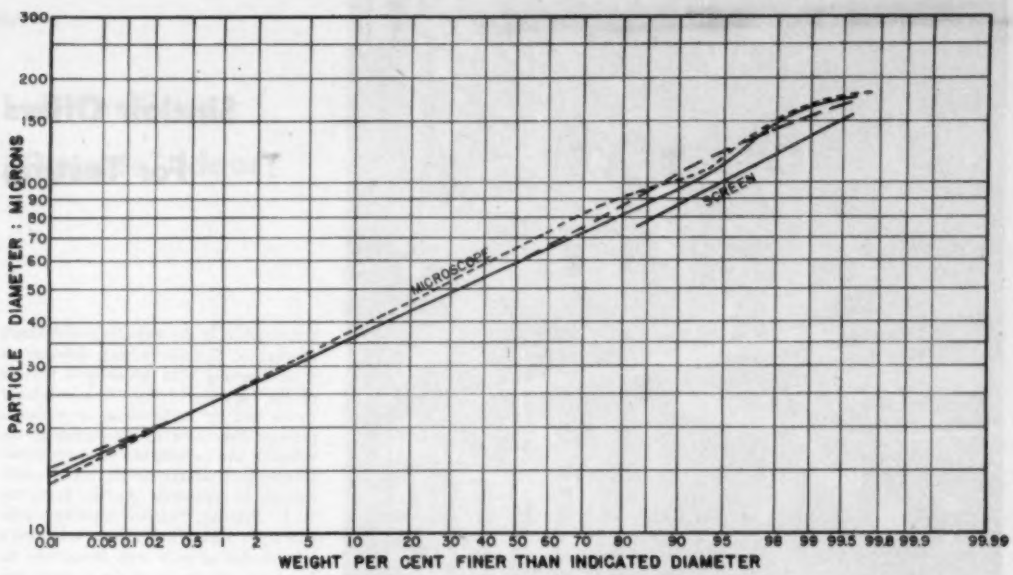

Figure 1. Microscopic and Screen Examination of Microspherical Catalyst.

maximum spread is ± 6 weight percent of sample. Herein lies ample indication of the fact that a single microscopic examination of a sample would not provide a satisfactory method of particle size analysis, even though the time element was not critical and the most skilled technicians were available. Using the average of the three counts, the screen analyses averaged 4.4 weight percent higher than the count at the 100-mesh (105-micron) level, and 14.5 percent higher at the 200-mesh (74-micron) level. At first glance, this appears to present a contradiction to the theory of screening. For example, Taggart[8] indicates that the screen efficiency (defined as the ratio of the undersized material passed to undersized material in the feed) decreases with increasing screen fineness, and explains that this is the case because of many factors among which are the relative dimensions of particle and screen opening, the proportion of particles in the feed whose diameters closely approximate the screen opening size, interference between particles, and the angle and velocity of the particle's approach to an opening. These considerations have the practical effect of producing screen analyses which show a coarser distribution than is actually present. But it is observed that the above screen data show a finer distribution than is known to exist.

The explanation of the anomaly lies in the screen specifications themselves. Consider that a screen which has any openings whose size exceeds the nominal must then pass material which is oversized as judged by the nominal opening. Furthermore, the percentage of material so passed will be related both to the number of oversized openings and the extent to which these openings exceed the nominal. With this in mind, the items shown in Table C from the screen specifications become specially significant.

TABLE C

	140 Mesh	200 Mesh
Nominal Opening: Microns	149	74
Maximum Opening: Microns	209	118
Maximum Range from Nominal Size Within Which 5% of Openings Can Lie	170	96

Thus, in the case of the nominal 74-micron screen, openings as large as 118 microns can exist and 5 percent of the openings can lie between 74 and 96 microns. When it is realized that as high as 15 percent of a catalyst particle distribution lies within the 74 to 96-micron range, it then becomes reasonable to expect that a screen meeting the above specifications will exhibit the bias toward fineness which the data show. However, since screening appears to be the only satisfactory method of particle size analyses in the range above 80 microns, we are then forced to accept deviation from the true particle size distribution, this deviation becoming more pronounced as screen mesh becomes finer. At this writing, no adequate means has been found for resolving the difficulty.

End of Part I. Part II will appear in an early issue.

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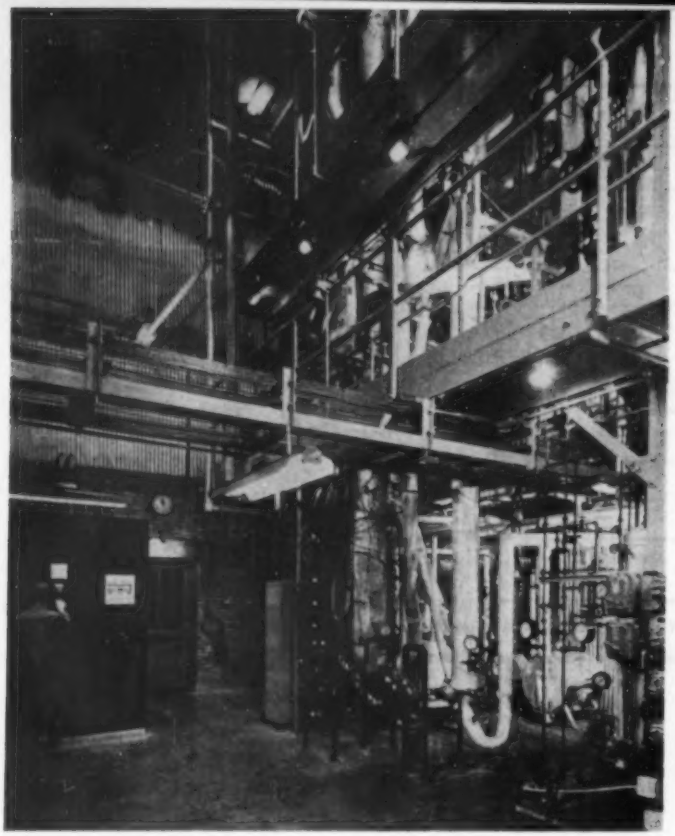
Sinclair Offers For Testing



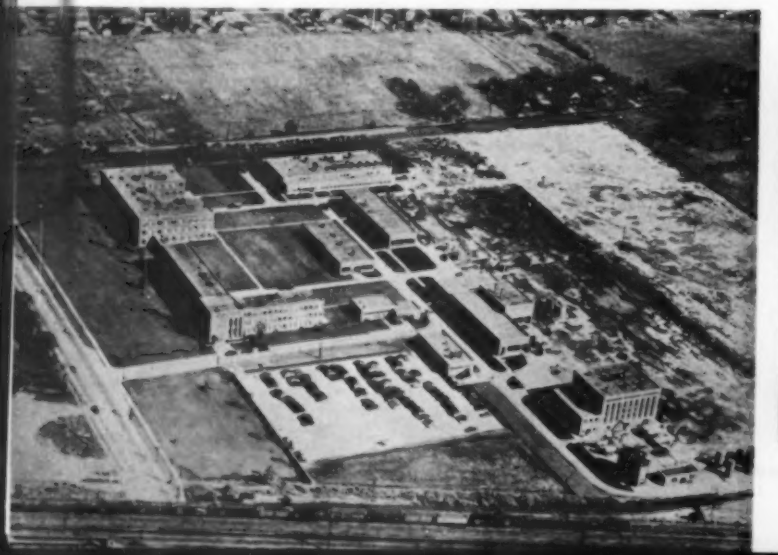
SINCLAIR Oil Corporation's research facilities—born prior to the first World War in a row of bare shacks, dubbed "nut houses," around the perimeter of the East Chicago, Ind., refinery—have been developed through the years to become among the largest and most complete in the petroleum industry. The present multi-million dollar laboratory plant was opened at Harvey, Ill., in late 1948, just south of Chicago and 15 miles west of the East Chicago refinery.

With the need for new ideas a constant factor in the petroleum industry's operations, Sinclair recently formulated a far-reaching plan whereby a portion of the capacity of the Harvey laboratories will be made available to independent inventors for researching, developing and proving out ideas for better petroleum products, or for better applications of products. As set forth by P. C. Spencer, Sinclair president, who conceived a plan to open the company's laboratories to men with ideas, and E. W. Isom, chairman of the recently organized Sinclair Research Laboratories, Inc., which owns and operates the research assets of the Sinclair companies: "It is the intention of the laboratories to seek out people with ideas, whoever and wherever they are. Nowhere is there a monopoly on ideas—the best may spring from the most unexpected quarters. A man and an idea are no longer enough to move our technological machine. There must be a third and fourth factor today—facilities and money."

Under the plan, people with ideas for better petroleum products or applications will be invited to submit them to Sinclair's research organization, providing every idea first is protected by a patent or patent application by the inventor. After screening, ideas showing the most promise will be put through

Above—View of Fluid Catalytic Cracking Pilot Plant, Sinclair Research Laboratories, Harvey, Ill.

Below—Aerial View of Sinclair's New Research Laboratories.



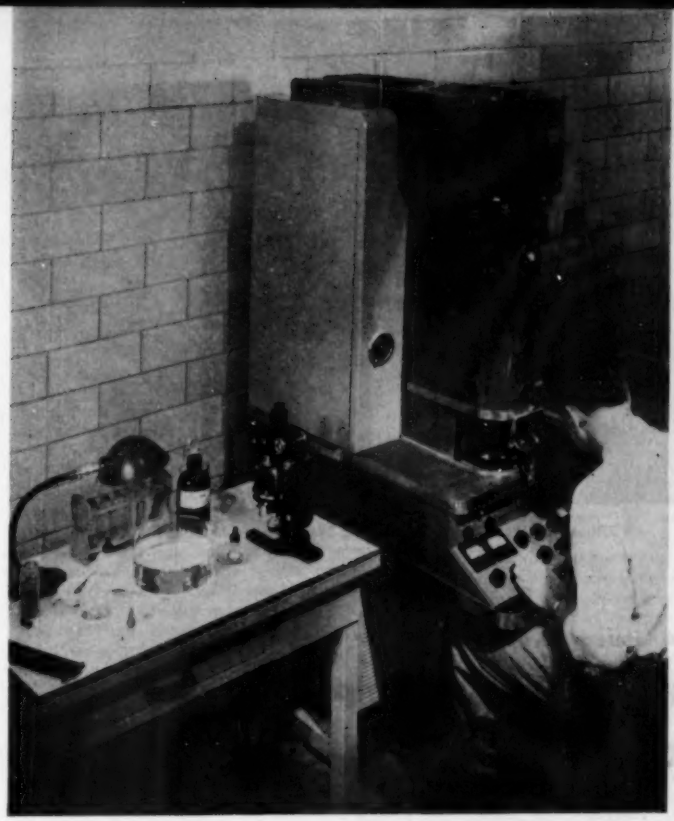
W. M. FLOWERS
Executive Vice President, Sinclair Research Laboratories, Inc.

Lab Facilities "Outside" Ideas

every phase of analysis, developing and testing that may be necessary to prove its commercial or scientific value. In most cases, Sinclair will make arrangements with inventors of ideas where in return for its investment of money, time, facilities and personnel, the company will receive the privilege of using the invention free of royalties. This, the company stated, will not prevent the inventor from selling his ideas to others or from full use of the idea by the inventor.

Operating on a current annual budget of $5 million, Sinclair's Harvey laboratories are staffed by more than 550 persons, including chemists, physicists, engineers, technicians and representatives of more than a score of professions. Nine buildings are located on a 38-acre tract housing facilities that make it possible for a scientist to take an idea from the roughest scratch-pad state and carry it through to final pilot-plant testing. Five major pilot units are installed in the 54-foot high pilot laboratory building. A three-barrel-daily fluid catalytic cracking pilot plant is the largest, requiring almost as much instrumentation as its 30,000-barrel-daily commercial counterpart. Other pilot plants include a four-barrel-daily continuous vacuum still, a thermal cracking unit, propane and deasphalting plant and a catalytic reforming unit. A complete tank farm with capacity for 221,000 gallons is located adjacent to the plants.

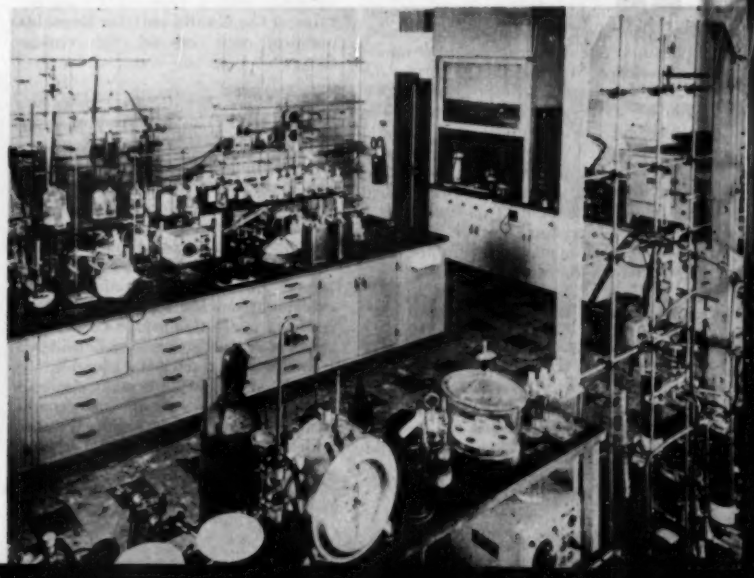
Other laboratory units at Harvey include the main laboratory building with 65 laboratories for complete analytic testing of various types, an engine laboratory, a lube and grease preparation laboratory, a fuel application laboratory, and exploratory and research facilities of a micro-pilot plant size to evaluate new methods prior to tests in the full-size pilot plants.



Above—Technician Working 100,000X Electron Microscope at Sinclair Laboratories.

Below—General Organic Research Laboratory at Harvey.

E. W. ISOM
Chairman of Board, Sinclair Research Laboratories, Inc.



A 250-gpm Oil-Water Separator Employing Chemical Flocculation and Dissolved Air (Courtesy Bulkley-Dunton Pulp Corporation).

A Literary Review —

Fundamentals and Performance Of Gravity Separation

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SETTLING operations are of common occurrence in oil refineries. This article provides a rather thorough review of the available information on the settling velocity of particles, the settling of suspensions, sedimentation in fill and draw basins and under continuous flow, sediment transportation, design criteria for settling tanks, the use of tracers and models, and the separation of particles lighter than water.

Originally presented to a session on refinery waste water at the API's Division of Refining meeting in Tulsa in May, some revisions have been made.

A) On the Settling Velocity of a Particle

THE subject of the motion of spherical particles through a fluid, with which the process of separation is primarily concerned, has interested many of the great minds of science. Sir Isaac Newton,[58a] in the fifth corollary of Proposition XXXV in his *Principia* (1686), states: "The resistance of the globe is in a ratio compounded of the duplicate ratio of the velocity, and the duplicate ratio of the diameter, and the ratio of the density of the medium." This later became known as Newton's law of resistance, which, in modern terminology, is written for the drag force as:

$$F_D = C_D \rho A \frac{V^2}{2} \qquad (1)$$

in which A is the projected area ($\pi \frac{D^2}{4}$ for the sphere); ρ is the fluid density; and C_D is the drag coefficient. By varying C_D, this equation can be made to fit a body of any shape in any fluid. In making this proposition, however, Newton was concerned solely with inertial effects—neglecting entirely the forces of fluid friction. That is why his equation, with a reasonably constant value of C_D, is valid only for Reynolds numbers well beyond the viscous range.

Stokes' Law

Almost two centuries later, in 1850, Sir George Stokes[72] wrote his classic paper "On the Effect of the Internal Friction of Fluids on the Motion of Pendulums." It is interesting to observe now that the case of the steady motion of a sphere in a viscous medium was originally but a byproduct of the larger problem. Indeed, there is no evidence from his report in the *Proceedings of the Cambridge Philosophical Society* that Stokes even considered it worthy of a separate equation. It would have required a mathematician indeed to deduce from his general pendulum equation the simple formula which is commonly called Stokes' law:

$$F_D = 3\pi\mu VD \qquad (2)$$

As the word "viscosity" was not yet in scientific use, Stokes named the coefficient μ the "index of friction" of the fluid. In a later revision of his first paper he expanded the section on the uniform motion of a sphere—acknowledging some experiments by Coulomb which confirmed his theory. He decuced the equation for the steady fall of a spherical particle in a quiescent fluid by equating the net gravitational force on the particle to the drag force in equation (2) (Figure 1). This form of Stokes' law:

$$V = \frac{g}{18\mu}(\rho' - \rho)D^2 \qquad (3)$$

is the one most frequently used as a starting point in the theory of sedimentation (which, for this purpose, applies equally to separation by flotation, inasmuch as the two processes are generically the same). Obviously, when the particle density ρ' is less than the fluid density ρ, the particle will rise instead of fall.

Refinements

Many mathematicians have attempted refinements to Stokes' law. Cunningham,[18] for instance, considered the case where the particles are small compared to the mean free path of fluid molecules. He calculated that, for particles of 10^{-5} cm diameter falling in air, Stokes' law gives a velocity about half the actual. He also considered the mutual influence of many particles in a cloud, and concluded that, so long as the distance between particles was at least 10 times the particle size, Stokes' law was not appreciably affected.

Smoluchowski[70] investigated the case of slip at the boundary of the sphere; and he developed a formula, applicable to the case of a fluid sphere in a fluid medium, which included the vis-

cosity of the fluid in the sphere as well as that of the medium. He also studied the upper limit of Reynolds number for which Stokes' law was valid, and concluded that accuracy within ½ percent would be obtained so long as the Reynolds number (based on the diameter) did not exceed 0.44. Bond[9] also considered the liquid sphere case, and deduced that Stokes' law is not appreciably affected so long as the viscosity of the sphere liquid is large compared to the viscosity of the surrounding fluid. However, in cases where the viscosity of the sphere is much less than that of the surrounding fluid, Stokes' law gives terminal velocities which can be as much as 50 percent too high.

Variation of Drag Force with Reynolds Number

Among those who have refined the equations for the drag force and subsiding velocity of spherical particles, Lunnon[48] has divided the variation of drag force with Reynolds number into three regimes. For the viscous regime, at low Reynolds numbers, Stokes' law holds, and drag force varies with the velocity. In the turbulent regime, at high Reynolds numbers, Newton's law holds fairly well, and the resistance varies with the velocity squared. Between these two lies a transition range in which the drag force varies with the $\frac{3}{2}$ power of the velocity, as expressed in an equation by Allen. Lunnon extended this theory to include non-spherical particles, particularly as encountered in ore dressing and coal washing.

Slade[65] has investigated the dynamics of sedimentation from the standpoints of mechanical theory and experiment. He points out that a particle in a liquid will move only as there acts upon it a net force, and that "at all times (except during negligible intervals of acceleration) the downward speed of the particle is the algebraic sum of its hydraulic value and the vertical velocity components of the fluid." Slade has developed a number of formulas for evaluating some of the factors influencing sedimentation. Most of the numerical values must be determined by experiment, however, in order to make his theory practical for designers.

The most recent work on the pure problem of particle-settling velocities is that by McNown and Malaika.[50] They present new tests and new theory on the effects of particle shape on settling velocities at low Reynolds numbers. They have experimented with various ellipsoids, cylinders, and double cones.

Many other authors have contributed to the understanding of the refinements on the motion of particles immersed in fluid. Several such papers, mathematical and physical in nature, are listed in Supplementary Bibliography "A," hereinafter.

B) On the Settling of Discrete and Flocculent Suspensions

A number of investigators have dealt with the case of suspensions or slurries so dense and well behaved that the subsidence of the sludge line could be clearly observed and plotted against time. Ward and Kammermeyer[80] recognize three distinct zones of such settlement. The sludge line falls initially at a constant rate, next at a second constant rate less than the first and, finally, at a logarithmically decreasing rate as the sludge blanket compacts against the bottom (Figure 2). They point out that the viscosity of the suspension is materially affected when the suspended-solids concentration is more than 3 percent. Robinson[61] has attempted to take this into account, as well as the change in density of the settling suspension, in a single formula which fits all regions of the settling curve. After a determination of the rates of change of viscosity and density for a certain suspension, the formula is applicable to this suspension.

Particle-Size Distribution

In order to study the settling of a suspension thoroughly, it is necessary to determine the distribution of particle size in the suspension. Kelly[46] has devised an ingenious arrangement in which the main suspension settles in a glass cylinder (Figure 3). Attached to the bottom of the cylinder is a side arm with clear liquid in it, terminating in a capillary slanted at 1.5 degrees to the horizontal. As the suspension settles (in accordance with Stokes' law), the density in the main cylinder decreases and the meniscus in the side arm falls measurably. The particle-size distribution can be computed from the rate of fall of the side-arm meniscus.

A different type of distribution classifier is suggested by Rouse,[63] who has made a study of the suspension of sediment in upward flow. The fine particles are carried to the top of the suspension while the grading gets progressively coarser toward the bottom. A classifier can be made on this principle, utilizing variable flow rates, and giving a distribution of settling velocities. For sediment study this information is more valuable than a size distribution obtained from an ordinary sieve analysis. A host of writers has contributed to the information on methods of determining particle-size distribution. Many such papers, practically all experimental, are itemized in Supplementary Bibliography "C."

Settling of the Sludge Line

The upward flow of water around settling particles was taken into account by Work and Kohler[84] in experiments with the sedimentation of chemical precipitates in still cylinders. By observing the rate of fall of the sludge line, they were able to define two regimes in the settling process, viz., a constant-rate period and a falling-rate period. In the initial, or constant-rate period, the settling velocity is decreased only by the upward movement of displaced water. In the falling-rate period the particles actually interfere with one another, by proximate and direct contact. In the upper part of the falling-rate period, Work and Kohler propose an analogy to pipe flow, in which the falling particle is likened to the flow of liquid in a pipe whose diameter is the reciprocal of the particle concentration. This analogy produces one interesting curve, but the reasoning is a little vague, and one of their conclusions involves a Reynolds number which is not dimensionless—indicating that a more careful review of the suppositions is in order.

Burgers[7] was another to conduct fundamental studies on the sedimentation of suspensions. He calculated an "effective viscosity" of the suspension which increases with the particle concentration, and which contains a factor dependent on particle shape. He found the speed of sedimentation to be a function of the distance between particles and the shape of the containing vessel.

Flocculation

Many writers have proclaimed the advantages of natural and artificial flocculation in settling a suspension. As Egolf and McCabe[22] state: "If solid particles in suspension bear a like charge, they repel each other, each retaining its individuality, and are said to be dispersed. If the proper electrolyte (coagulant) be added to the suspension, so that the charge on each particle is neutralized, the natural forces of attraction between the particles cause two or more of them to aggregate into a floc." Their experiments dealt entirely with flocculated suspensions, and this is one of the better references on that subject.

Perhaps the best treatment of non-spherical particles, both in and out of flocculated suspensions, is contained in the comprehensive treatise on sedimentation rates by Steinour.[72] Working with angular particles of emery powder, he found that such particles

settled at a rate different from that of spheres, but they approached closely the values calculated for hypothetical spheres made by adding to the particle the stagnant volume of liquid caught in the angularities. This enabled computing the "specific surface" of non-spherical particles, or the ratio of surface area to volume of a perfect sphere having the same density and the same rate of fall as the particle in question. The specific surface is a characteristic of some importance in the dispersion of cement pastes. Steinour's articles contain good bibliographies relating to sedimentation of both spherical and non-spherical particles. Further papers on the engineering aspects of sedimentation, density currents, and turbulence are listed in Supplementary Bibliography "B."

C) On Sedimentation in Fill and Draw Basins

One of the earliest published papers in the United States on the subject of sedimentation is that by Seddon[67] on "Cleaning Water by Settlement," which appeared in 1889. Seddon studied the settling basins at St. Louis which were at that time operating intermittently—turning the river water into one basin while allowing it to settle in another. In his experiments he found that the region near the bottom clarified more quickly than predicted from a straight application of constant settling rate. This apparent acceleration of particles as they progressed downward he attributed to a retardation of the particles before they actually commenced to settle. In his explanation, however Seddon failed to take account of the upward movement of the water which is displaced by the downward movement of the particles. It is also interesting to observe that, although allowing for wind and temperature effects, he discounted completely coagulation and flocculation which, half a century later, were deemed to be the chief factors effecting an apparent acceleration of the settling suspension.

After many years of inactivity in the field, the problem of sedimentation in basins with no through flow was attacked theoretically by Slade[69] in 1937. He improved on Hazen's[36] earlier considerations by taking into account the variation in particle size in a solids' suspension (which Hazen had assumed to be uniform). This he did by means of a distribution function relating to the particles' time of subsidence. The distribution function was a characteristic of the sediment alone, and could be determined from a simple test on a sample of the sediment in a quiescent glass cylinder. The distribution function could be applied to a suspension in which the particle size varied gradually or one in which the size gradations were in discontinuous steps.

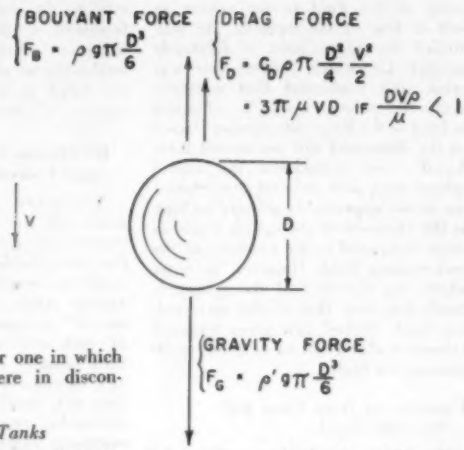

Figure 1. The Forces Acting on a Particle Settling at Constant Velocity.

Turbulence in Settling Tanks

In addition to the hypothetical quiescent basin, tanks with three degrees of turbulence were included in Slade's analysis. "Incomplete" turbulence was taken to mean eddying motion so slow that it affected the settling of the suspension only by increasing the time allowance necessary for a particle to settle through the depth of the tank. "Complete" turbulence was taken to mean the state in which the basin is sufficiently mixed so that the density and size distribution of the suspension is uniform throughout the tank; but a particle, once settled out, remains so. "Critical" turbulence applied to a condition in which the mixing was so violent that any particle which was about to settle out would be immediately swept back into the suspension.

Slade next pointed out that any solids' suspension could be divided into three groups: *a*, those particles having times of subsidence up to t_1 for which the prevailing turbulence could be considered incomplete; *b*, those particles having times between t_1 and t_c for which the turbulence was complete; and *c*, particles with subsiding times above t_c for which the turbulence was critical. The values of t_1 and t_c were functions of the agitation in the tank. The removal rate for a basin could then be predicted by considering the theoretical removal in each of the foregoing categories (zero for the last group) and by adding them. Summing up his theory, Slade states that his equations will predict removal rates after three fundamental types of constants have been evaluated experimentally. These groups are: 1) those which represent characteristics of the sediment, as the distribution function; 2) those which represent characteristics of the basin, as the turbulence limits; and, 3) those which depend on both the sediment and the basin, as the time factors in the incomplete turbulence regime.

The reviewers of Slade's paper took him to task for not taking into account the important effects of flocculation in his distribution function. Moseley[57] pointed out that the degree of flocculation varies markedly with the density of the suspension. Thus a settling tank having a detention period of 1.5 hours will remove approximately 60 percent of the suspended solids of a raw sewage of 400 ppm., but only about 45 percent from one of 100 ppm. The difference is accounted for by the flocculating action in the suspension. Slade countered by stating that his distribution function covered the case of flocculation in which statistical equilibrium had been reached—which, he maintained, required but a short time.

Camp[9] observed that a distribution function based on hydraulic values (rates of fall) was much easier to work with, as it obviated the need of sidestepping the suspended colloid particle for which the time of subsidence approached infinity. Camp also developed the approach to his overflow-rate theory which he had presented in his earlier paper.[8]

The most recent work on sedimentation in fill and draw basins is that by Dobbins[20] in 1944. He experimented with a cylindrical chamber which was kept in a steady state of fully developed turbulence by a mechanical mixer. In fully developed turbulence, it is possible to measure such quantities as mixing length and diffusion coefficients. These and other concepts of modern fluid dynamics Dobbins has put to use in developing a theory on the effect of turbulence on sedimentation.

D) On Sedimentation in Continuous-Flow Basins

Allen Hazen,[36] in his classic paper

"On Sedimentation," in 1904, analyzed various cases of continuous flow basins together with intermittently operated ones (Figure 4). He was perhaps the first to appreciate the significance of what was later to become known as overflow rate, and he stated emphatically that the depth of a given basin handling a given flow is of no importance provided the bottom velocities are not so high as to entrain particles which have already settled out. His second principal conclusion was that longitudinal mixing must be reduced to a minimum if a settling tank is to be efficient; "the best results are obtained when the basins are arranged so that the incoming water containing the maximum quantity of sediment is kept from mixing with water which is partially clarified."

It is interesting to note that in no one of his 15 hypothetical propositions did Hazen resort to the simple "uniform flow" theory with which most modern writers, e.g., Camp,[11] on the subject prefer to start. In all of his continuous-flow cases he assumed complete mixing in the basin, but he also showed that sedimentation takes place in a basin with mixing. His calculations led him to state that a series of basins in tandem is better than a single basin of the same overall length, as the detrimental longitudinal mixing is thereby reduced. He recognized that good baffling would accomplish the same results as the separate basins in series; but, even with infinite baffling, such a basin would still be far inferior to what is called an "ideal tank." However, Hazen admitted of nothing superior to this, with the exception of the Rockner-Rothe type of basin with overflow skimmers taking the clear water from the top of the basin at a great many points. Using his sedimentation theory, Hazen also included in his paper an analysis of the filtration process—pointing out that the pores of a sand filter actually operate as so many tiny sedimentation basins.

Hazen readily acknowledged that little was known about scouring velocities. He reasoned that, if the velocity impinging against a particle resting on the smooth bottom were as great as the unimpaired rate of fall of this particle, it would be entrained. He stated that some tests had shown the mean velocity in a basin to be some 20 to 40 times as great as the bottom velocities.

Beneficial Shortcircuiting

One thing in Hazen's paper is of especial interest. He theorized that (what is now called) shortcircuiting across the top of a basin is not at all detrimental; in fact, it may even be desirable. The overflow rate for the upperpart of the basin is exactly the same as for the basin as a whole, and the large dead space under the current acts as a perfect receptacle for sediment without concern for bottom velocities.

Fuller,[24] in his discussion of Hazen's paper, substantiated to an extent Hazen's theory on dead spaces by citing the case of the Louisville reservoir in which the flow was directed diagonally from one corner of a square reservoir to the opposite corner. When the reservoir was cleaned after years of operation, just as much sediment was found under the dead spaces in the odd corners as in the more active parts of the reservoir.

One of the first to make a strong positive statement in favor of continuous-flow sedimentation basins (a complete reversal from Seddon's earlier views) was Deane[19] in his "'Settling' Problems" in 1920. He refers to a "continuous thickener," and distinguishes carefully between the two requirements of producing a clarified liquor on the one hand and, on the other, a thickened pulp of minimum moisture content.

First Attempts at Rational Design

In the first of his many contributions to the literature on sedimentation, Camp,[8] in 1936, outlined his views on the rational design of settling tanks. Following Hazen,[36] he held that overflow rate (flow divided by surafce area) must be the reigning criterion in designing for the capacity of a settling tank. From a curve of the distribution of settling velocities among the particles of the suspension, it is possible to determine the theoretical removal which can be expected of a settling tank.

Camp observes that, whereas Hazen assumed that all mixing retards settling, a gentle mixing will promote flocculation which actually accelerates settling. He analyzes the forces acting on a settling tank as; *a)* inertial; *b)* viscous drag; and, *c)* gravity. Inertial and viscous forces are stabilizing, whereas gravity is an unstabilizing force—particularly when there are fluid masses of different temperatures and, hence, different densities in the tank. If the ratio of stabilizing forces to unstabilizing forces (i.e., the Froude number) is large, the tank is stable, and the performance is consistent. If the ratio is low, the tank is likely to be unstable, and the performance will be erratic. These things are discussed further in connection with hydraulic characteristics.

E) On the Transportation of Sediment

On the subject of sediment transport, Gibson[26] (p. 430) observes that the erosive power of water varies as the square of the velocity, whereas the transporting power varies as v^6. He states further: ". . . a stream which carries a certain amount of fine material in suspension has a greater capacity for transporting larger material than one which carries only the larger material."

The effects of turbulence on the transport of sediment have been attacked with modern fluid-dynamics theory in papers by Dobbins[20] (previously discussed) and Vanoni.[79] The findings from Vanoni's experiments are not readily applicable here, as the velocities involved are from 200 to 400 times those found in separators.

Scouring Velocity

Using particles of quartz and galena, Rubey[64] conducted settling velocity experiments which led him to an equation combining the regions of applicability of Stokes' law and Newton's law. He concluded also that the current required to move a particle along the bottom of a channel, once it has settled out of suspension, is approximately the same as the particle's settling velocity in still water. This agrees with the conjecture made by Hazen[36] 30 years earlier.

F) On Criteria for the Design of Settling Tanks

Complementing the theoretical developments championed by Hazen, Slade, and Camp, a comphehensive paper covering the practical aspects of factors affecting sedimentation was presented by Schroepfer[65] in 1933. These he classified as follows:

a) Characteristics of the Liquid: Of these the most important is viscosity. The velocity of subsidence is increased 129 percent by an increase in temperature from 0 to 30 degrees C. Changes in specific gravity are of lesser importance percentagewise, but can cause density currents which give rise to serious shortcircuiting.

b) Characteristics of the Solids: Particle size is the most important feature here. For sand, the velocity of subsidence varies with the diameter of the particle as follows:

(1) 1.0 mm and larger, as the square root of the diameter.
(2) 0.1 to 1.0 mm, as the diameter.
(3) 0.1 mm and smaller, as the square of the diameter.

As for shape of particles, any shape departing from the spherical simply increases the ratio of surface area to volume, and thereby increases the skin friction and decreases the hydraulic value. Variations in specific gravity become of increasing importance as the specific gravity approaches unity,

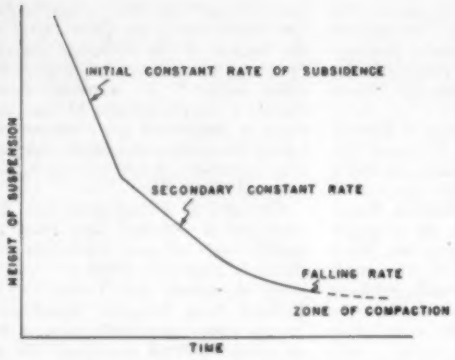

Figure 2. Subsidence of the Sludge Line for a Dense Suspension (after Ward and Kammermeyer[20]).

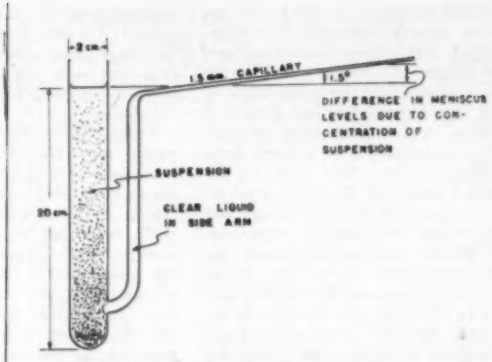

Figure 3. Tube for Determining Distribution of Particle Sizes in a Suspension (after Kelly[34]).

inasmuch as the subsidence velocity is proportional to the difference in densities between the particle and the fluid. Concentration of particles can affect the density of the influent to an extent. It is well established experimentally that removal varies directly as the solids' concentration. Flocculation, coagulation, and coalescence are important factors—all of them increasing removal rates; but they are difficult to predict without specific data on the suspension at hand.

c) Characteristics of the Design: The most important of these is detention time. Schroepfer quotes various investigators who report flowing-through times between ⅓ and ½ the theoretical detention period. These represent uneconomical designs. There exists a wide difference of opinion on the maximum velocities allowable in sedimentation basins—roughly, from 1 to 10 feet per minute. The bottom velocity should be less than the hydraulic value of the smallest particles to be settled (after Hazen[36]). High bottom velocities may be caused by temperature effects and inlet and outlet designs. As for depth of tank, Schroepfer takes issue with Hazen, and shows that removal varies inversely with depth. However, in comparing tanks of given length and velocity, he misses Hazen's concept of comparison on the basis of overflow rate. Thus his conclusions actually confirm Hazen's stand on overflow rate.

Schroepfer includes, under the "design characteristic" heading, inlets, tank shapes, and baffling. The purpose of an inlet is "to produce conditions of uniform flow across substantially an entire vertical cross-section and to prevent partially settled liquor from being mixed with the unsettled incoming fluid." Baffling is used to accomplish much the same purposes; also to reduce dead spaces. As for tank shape, there are arguments for a converging or diverging tank, but they are self-conflicting and not strong enough to warrant a departure from the convenience of a rectangular or circular tank. Bottom area should be as great as possible (after Hazen[36]), and mechanism velocities should be less than 8 feet per minute.

d) Miscellaneous Effects—including currents caused by wind, eddies, and temperature difference; biological activities; and electrical effects—are all highly variable, and mostly of minor importance.

Inlet Velocity Distribution

A number of writers have contributed to the understanding of settling-tank design criteria. Baylis[5] states that, with an influent bearing considerable sediment, it is foolish to devise a complicated inlet structure to distribute the flow, as it will be carried straight to the bottom anyway until it drops some of its heavy sediment load. The inlet velocity should be reduced as far as is easily possible, but one should be satisfied to get it as low as 5 feet per minute. A uniform velocity distribution of 1 foot per minute is beyond all possibility. He recommends a second tank in which the partly clarified liquor can settle without danger of mixing with the sediment-laden influent.

Imhoff[41] states that the most important inlet consideration is that the velocity be started off in a *horizontal* direction. Vertical currents, either up or down, are undesirable in sedimentation—especially so when the basin is overloaded. Imhoff also divides sediment into two fundamental classes which require different design approaches. Granular sediment should be approached on the basis of overflow rate, whereas floccular sediment must be handled from the standpoint of total tank volume or detention time. Camp[9] has pointed out that the design of a settling tank must consider three fundamentally different zones, viz.: a distributing zone at the inlet, a settling zone, and a collecting zone at the outlet (Figure 5). Each must be designed to accomplish its specific purpose.

Keefer,[45] in the 1940 edition of his sewage-treatment textbook, is one of many examples of Camp's statement to the effect that many sedimentation basins are designed from consideration of detention time alone. Overflow rate is not mentioned.

Baffles—Pro and Con

The use of baffles in sedimentation basins has been argued pro and con by many engineers. The question is largely a practical one, and does not lend itself so well to theoretical analysis as do other features of the sedimentation process. Hazen's concept of a baffle, which practically divides the main basin into separate chambers, has little significance today. Fuller,[24] in discussing Hazen's[36] paper, showed the paradoxical position of the baffle in sedimentation-basin inlets where "baffles are used . . . to accomplish diametrically opposite results, namely, to promote mixing or prevent deposition on the one hand, and to facilitate sedimentation on the other."

Hayden[25] reports that over-and-under baffles have been effective in reducing shortcircuiting in basins at Oakmont, Pa., particularly the shortcircuiting due to temperature gradients. Most observers, however, agree with the manual of the American Society of Civil Engineers: *Water-Treatment Plant Design*,[62] which points out that baffles are usually added after a basin has been built to correct some fault in the design. Any baffle in the settling zone of the basin is inherently undesirable, as it causes some mixing. At the inlet, however, a perforated or slotted baffle which comprises a diffusion wall can be very effective in

releasing the flow to the basin in a horizontal direction, and with good vertical distribution. The head loss across such a diffusion wall should be large compared to the minimum kinetic energy of the flow upstream. A head loss of 0.01 to 0.02 foot will produce desirable velocities, varying from 0.4 to 0.6 foot per second. A second diffusion wall is also recommended at the outlet end of the basin.

Inlets and Outlets

Giles[25] makes the general statement that "inlet devices which drop the flow into the settling compartment should be avoided. Such drops draw air entrapped with the flow, and give such a stirring action that the motion is never entirely lost." In recommending a flow distributor, such as a slotted baffle, Giles was one of the first to emphasize the need for straight approach channels in order to avoid circular currents. If the inlet to the basin is necessarily through pipes, considerable distribution can be obtained by placing sloping target baffles downstream from the pipes. These will deflect the flow upwards and downwards—removing the kinetic energy of the forward motion. Wittwer[63] makes the observation that the effects of inlet and outlet conditions on sedimentation are felt in inverse proportion to the length of the tank. In his paper, Wittwer also presents the most positive experimental evidence that removal rate increases with the concentration of the suspended solids.

Most observers agree that influent conditions are more important to the behavior of a separator than effluent conditions. Anderson,[1] however, takes almost the opposite view. He found, in tests on full-scale sewage-settling tanks, that no one of some 25 different inlet baffling arrangements appeared to be of benefit in reducing density currents from heavy activated sludge suspensions. On the other hand, he shows conclusive evidence that the quality of the effluent varies inversely with the discharge per unit length of effluent weir. He gives a maximum figure of 13.9 gpm per foot which should be reduced to 10.4 gpm. per foot if the weir is in the upturn zone of the density current.

Townsend[70] stressed the necessity for low-velocity multiple inletting. He agrees also with Anderson,[1] in that he stresses the importance of having low velocity of flow over the effluent weir. A tank with multiple weirs which extend into the settling zone, so that the weir rate is very low, is better than one without them, even though the distance from inlet to nearest outlet is thereby reduced.

Tests by Rohlich and the author[62] have shown that a horizontal slotted baffle at the inlet to a model separator produces a more satisfatcory distribution of velocities in the settling zone than is obtained with a free-fall inlet weir. Further tests by the author[42] substantiate the claims of most of the other investigators, i.e., that conditions at the inlet are far more important than those at the outlet.

Shape and Size

For a circular clarifier with a peripheral takeoff, Kalinske[44] states that the depth to the sludge blanket should not be less than about one-seventh the diameter of the tank. This will prevent the rising velocity's approaching the takoff from entraining solids removed in the sludge blanket. If this clear depth cannot be obtained, additional takeoffs should be provided.

On the subject of the optimum depth for a settling tank, Camp[13] has taken the view that a shallow tank is less subject to instability from density currents. Anderson,[2] however, claims that density currents are less prominent in deep tanks than in shallow ones. Experiments at Chicago showed that the velocity of density currents was in inverse ratio to the depth. Higher velocities of density currents were found in the shallow tanks of the Wards Island plant in New York.

Langelier[47] reports the ingenious use of a mountain water tunnel as a long sedimentation basin, with excellent results. The tunnel, which conducts water from the Alpine Reservoir in California, is 8700 feet long with a depth of about 10 feet. The maximum velocity is 12 feet per minute, which produces a detention period of 12.1 hours and an overflow rate of 0.0138 feet per minute. It is not surprising, therefore, to find that the tunnel, preceded by a 3.5-mile length of winding pipe in which coagulants are added and mixed in the flow, accomplishes a turbidity removal of about 98 percent and a color removal of 86 percent. Langelier states his opinion that, "in general, long, narrow, and shallow basins are likely to prove most efficient. For equal retention periods, basins of these proportions provide proportionally greater floor and surface areas, a minimum of so-called dead space . . . Of even greater importance . . . is the fact that in a basin of these proportions each particle of floc has a several-fold greater opportunity to collide with a surface, either bottom or side walls, become entrapped thereon, and consequently be removed from the water."

In a recent article by Poepel,[60] translated by Keefer, several criteria of settling-tank design are set forth. This paper aroused considerable controversy and became the subject of two protest papers, i.e., one by Gifft,[27] the other by McKee and the author;[49] it will not be considered further here.

G) On Hydraulic Studies Using Tracers and Models

Some of the earliest reference to the use of a tracer to study hydraulic behavior is found in the experiments of Clifford[15] in England in 1907. Using dye tracers and sodium-chloride dosing, he studied the passage of liquids through percolating beds. He found the first trace of the dose getting through the bed in practically no time, and the mean time was but one-third of the theoretical. He also utilized a technique of continuous dosing—starting with clear water, and observing the time required for the effluent concentration to reach that of the influent. This method, he maintained, provides a better measure of the overall displacement, as "the time of passage is proportional to the amount of liquid held in motion by the medium." On these tests, also, Clifford[16] reached the important conclusion that "the average forward movement of the molecules of a solute does not differ appreciably from that of the molecules of the solvent."

Some 25 years later Clifford[17] applied these techniques to the flow of sewage in precipitating tanks. He found that one-third of the volume of most tanks is wasted. He points out that the kinetic energy of the fluid entering a tank must be absorbed by turbulence and ultimate heating in the tank. Inlet velocities, therefore, should be kept low. With too little inlet energy, on the other hand, as in low flow rates, the tank is liable to have severe shortcircuiting and large dead spaces, as there is not sufficient energy to keep all the liquid in motion.

Shortcircuiting

The sodium-chloride technique was also used in tests by Capen,[12] in 1927, on eight different sewage-settling tanks. He found flowing-through periods from 9 to 48 percent of the theoretical detention time, with an average around 30 percent. (Capen's "flowing-through period is the mean detention time. See Figure 6.) The best tanks were those with distributed, submerged inlets with no baffles, and with distributed weir outlets. He found inlets to be more important to hydraulic efficiency than outlets. He also concluded, from his studies that depth and velocity have little importance in tank design, and that the optimum length-width ratio for a tank is between 4

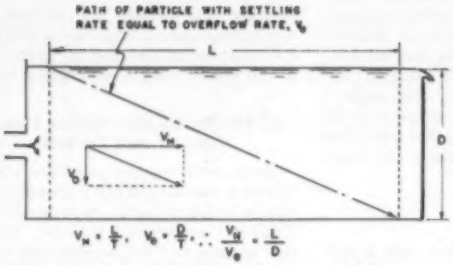

Figure 4. Fundamental Process in a Sedimentation Basin as Conceived by Hazen.[35]

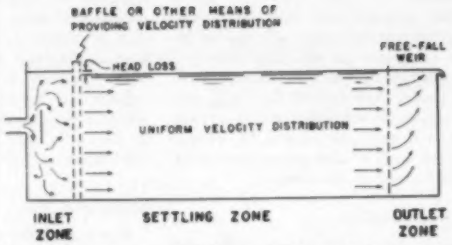

Figure 5. The Three Functional Zones of a Settling Tank (after Camp[7]).

to 1 and 5 to 1. Retention efficiencies did not always agree with hydraulic efficiencies, but were somewhat consistent.

Severe shortcircuiting in full-scale settling basins seems to have been fairly common. Schroepfer[66] reports a case of a sewage-settling tank with a flowing-through time of only 10 percent. This figure seems barely credible today. It may well be that density currents caused by the tracer, (as is frequently the case with sodium-chloride dosing) are the explanation.

The use of various tracers is particularly adaptable to the study of hydraulic behavior of settling tanks by means of model testing. Among the first investigators to experiment with this technique were Babbitt and Schlenz.[4] Using a dose of 1 kg. of sodium chloride dissolved in 3 gallons of water, they conducted a test on the flowing-through chamber of a 10-foot-diameter model of an Imhoff tank. Their results showed extraordinary delay in the appearance of the salt in the effluent—the peak not being reached until after the theoretical detention time. In the light of more recent tests, it is believed that this could have been caused only by the sinking of the dense brine to the bottom, where it remained too long. With no precedent in the matter, however, Babbitt and Schlenz concluded that the displacement detention time is a sufficiently accurate picture of the true detention time.

Separator Model Laws

Carpenter and Speiden[13] were among the first to seek the model laws which were followed by the sedimentation process and the flow through a settling tank. They maintained that the basin must be operated in accordance with Froude's law,* particularly the inlet and outlet conditions; but that the size and concentration of particles in the influent should be the same as those for the full-scale basin. It is then "reasonable to assume that the percent removal of suspended solids in the prototype will be approximately the same as in the model." In this statement, however, they either overlooked or neglected Hazen's theory of retention based on overflow rate; for, with model operation on the basis of Froude's law, the overflow rate varies, as does the velocity, with the square root of the scale ratio. Carpenter and Speiden also speak of the hydraulic efficiency of a basin as the flowing-through time divided by the theoretical detention time. They define flowing-through time to be the mean detention time. Some of their tests were made with a conductivity cell to measure the concentration of the sodium-chloride tracer used. This was unsatisfactory in all but the clearest water, as sediment would gather quickly on the electrodes and affect the measurements.

Mixing Chambers

Numerous investigators have applied the dispersion-testing technique to the flow in flocculating and mixing basins. In fact, usually the mixing basin, baffled to keep the liquid near the influent from mixing with that near the effluent, has a better-looking dispersion curve than a sedimentation tank. The Jeffrey Company[42] has tested a long flocculating basin, both with and without baffles. Although the basin shortcircuits seriously without baffles, the flow is close to ideal when a long tank is divided into successive chambers, each provided with an influent target baffle on the mixing shaft. Much the same results were observed by Nichols,[59] who found that the dispersion index† was reduced from 5 to 2.11 by dividing the straight tank into chambers and baffling out the spaces not in close contract with the mechanical flocculator. Sodium-chloride dosing provides no problem in the study of a mixing tank, because there is no tendency for it to settle to the bottom. Nichols says that the Froude law applies to the study of model flocculating chambers.

The use of the Froude law for mixing-tank study is verifield by Christensen and Morabito,[14] who tested cubically shaped mixing chambers. Although they found no similarity in flow patterns when Reynolds' law was used, their experiments revealed that Froude's law may be employed in model studies of mixing chambers and that, when paddles are used, Froude's law also applies to the peripheral velocity of the paddles. Echarte[21] experimented with round-the-end type baffles in a rectangular mixing chamber. He found that excellent hydraulic characteristics could be obtained—much better, in fact, than those of a settling tank—because of the high velocity and the amount of baffling which could be used.

Tolman[77] analyzed the basin model-testing problem, and concluded that: 1) when a model flocculating basin is studied with salt or dye, use the Froude law; 2) when the same basin is studied with actual floc forming, use the same detention time in model and prototype; and, 3) for a settling basin which actually removes solids, use the same horizontal velocity and overflow rate in model and prototype. Tolman says that a satisfactory flocculating basin should have a dispersion index of 2.5 and a satisfactory sedimentation basin should have one of 2.0 or less. This figure was achieved in the Detroit Springwells model test, but it has not been approached on tests by the author.[62]

Thomas and McKee[76] used sodium-chloride dosing and a conductivity meter to study longitudinal mixing in aeration tanks. They found that transverse baffles, which divide the tank into a series of chambers, reduced longitudinal mixing and shortcircuiting while promoting the desirable transverse mixing. Baffles are especially important for the case of dis-

* The relations of length, time, and velocity for the Froude model law are considered in detail in the manual of the American Society of Civil Engineers[35] on hydraulic models.

† The dispersion index is arbitrarily defined to be the detention time of the first 90 percent of the tracer dose divided by the detention time of the first 10 percent. (Figure 6.)

tributed loading. These authors formulated a mixing coefficient which was a function of the square of the tank length divided by the time required for the concentration at the end of the tank opposite the dosing point to reach 90 percent of C_o, the concentration which would obtain if all the dose were dispersed immediately throughout the tank (this test to be conducted with no flow through the tank).

Stability of Settling Tanks

In his first paper Camp[8] speaks of the stability of a settling tank as that property by which duplicate dispersion tests yield the same results. He cites a case in which two consecutive dye studies gave values of mean detention time of 1.15 and 0.82, respectively—thus indicating instability. The two flow patterns were also markedly different in profile; yet the conditions of the run were the same. Instability was always greatest at the low flows. He found that sodium-chloride dosing gave consistent results, but that they did not agree with results from dye dosing—thus indicating a density effect caused by the denser brine. Camp found that small temperature differences, by virtue of the differences in density, will move large masses of water and cause marked instability and shortcircuiting. As to model laws, he concluded that Reynolds number has little to do with sedimentation-basin study. The forces of the gravity differential mask the forces of turbulent exchange.

The American Water Works Association has published a manual[81] on water quality and treatment, in which there is a section on sedimentation basins and the model studies thereof. Displacement efficiency is defined to be the ratio of the average to the theoretical detention time. The manual says that "it is now common practice to insist on a displacement efficiency of at least 30 percent." In the light of results of other experimenters, this would represent a poor settling tank in which two-thirds of the volume was dead. Perforated baffles at inlet and outlet are recommended to give satisfactory distribution of the flow. There is no mention of overflow rate as a design criterion, further evidence of Camp's thesis that many sedimentation basins are built with the criterion of detention time rather than overflow rate. The 30-percent figure may have come from an article by Straub,[74] who conducted dye tests on small sedimentation-basin models. He found displacement efficiencies to increase with the Reynolds number up to a value of about 30 percent at Reynolds number 200 (probably based on hydraulic radius). From there on to higher flows the characteristics did not change much with either the Reynolds or the Froude number.

Moore, Smith, and Ruchhoft[55] have recently conducted detention-period studies on circular clarifiers which operate at theoretical detention periods of 135 minutes. They found median detention times between 62 and 68 percent of the theoretical; modal times between 33 and 52 percent; and dispersion indices between 3.5 and 5.1. Their method was sodium-chloride dosage, and they claim not to have experienced any ill effects from the differential specific gravity of the brine (which was used in sewage rather than clear water.)

The Detroit Tests

Much of the experimental work on hydraulic characteristics of sedimentation basins has centered around the city of Detroit. Hardin [29] reports the construction and testing of a 1:25 scale model of the settling basins at the Springwells filtration plant. Dyes and salt solutions were used to determine the pattern of the flow through the basins—the most valuable information having been gained by plotting the movement of the dye front down the tank. The inlet baffle, of vertical diverging slot-type, blocked 87 percent of the free area. Morrill[56] reports further testing of this model basin, in which guide vanes were introduced in the inlet to direct the flow horizontally into the basin. The dispersion index was thereby reduced from 3.65 to 1.67. Morrill states that the Froude model law gives the proper relation for dynamic similarity of sedimentation basins, although viscosity and surface tension play an increasingly important role as the model scale is reduced.

Hubbell[36] tested the hydraulic characteristics of various circular settling tanks under consideration for the Detroit sewage works. He tested 1:24 scale models by the Froude law, using dye and salts. He found that the most important objectives of circular tank design are to detain all of the flow for the longest possible time; to prevent high-velocity zones which can cause scouring; and to prevent regions of back eddies which indicate inefficient use of tank volume. He found the most satisfactory central inlet to be a multiple-plate diffuser of 4 to 5 plates, which spread the influent uniformly over the vertical section of the tank (Figure 7). Surrounding the diffuser was a spiral-flow baffle which aided in further reducing the influent kinetic energy and decreasing the shortcircuiting. However, as satisfactorily as the circular tank could be made, Hubbell[37] found, by testing rectangular tank models also, that a long narrow tank was even better. Again he experimented with various inlet arrangements, and finally adopted a submerged entrance with the flow striking a sloping baffle—part of it passing under and part over the lips of the baffle. He concluded that the rectangular tank had less shortcircuiting, and was more stable, than the circular tank.

Grit Chambers

Shortly after this, Hubbell[39] was testing grit-chamber models for the Detroit Sewage Treatment Project, using both hydraulic characteristic and sediment-removal techniques. He also tested field grit chambers, and was thus able to determine the accuracy with which performance could be predicted from model tests. He found a greater percentage of removal in the laboratory model than in the field chamber. The laboratory model, being tested in accordance with the Froude law, had velocities which gave turbulence considerably less than under field conditions.

In his discussion of this paper, Camp[10] makes one of the outstanding contributions to the understanding of sedimentation. Using a sieve analysis to give an approximate distribution of settling velocity, Camp predicts from his theory what the theoretical removal should be. He then defines sedimentation efficiency as the ratio of the actual to the theoretical removal. It is, to the author's knowledge, the first instance of a rational definition of efficiency applied to sedimentation basins. The observed results were within 10 percent of Camp's calculations. Furthermore, he took the shortcircuiting data and calculated what should have been the reduction in removal by computing the decrease in detention time for each 10 percent of the flow. Inasmuch as the model chambers had excellent characteristics, both the computed and the actual reductions in removal were nil, and the method was not altogether conclusive.

One of the recent advances in tracer technology has been made by Thomas and Archibald[75] in a study of longitudinal mixing in tanks. Radioactive tracers, in concentrations of 10^{-10} ppm. will provide clear signals of 1000 radiations per minute. In addition to the advantage thus obtained in eliminating all density-current effects, there is no effect from temperature change, or from biological or chemical action. Tracer clouds can be detected through conduit walls—thus eliminating the need for sampling.

Rational Analysis of Sedimentation

One paper which surpasses all others in scope of the over-all prob-

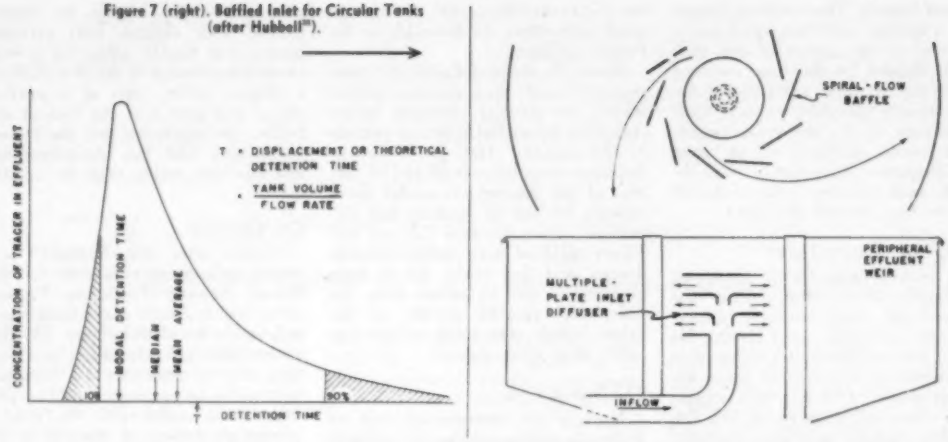

Figure 7 (right). Baffled Inlet for Circular Tanks (after Hubbell[29]).

Figure 6 (above). Typical Curve from a Dispersion Test of a Separator (after Ingersoll[22]).

lem of sedimentation is Camp's "Sedimentation and the Design of Settling Tanks,"[11] which appeared in 1945. In it the avowed intent was "to collect in one compendium the known principles of sedimentation essential to the development of design theory, and to present the theory of design developed to a stage which will permit its use in practice." In 10 sections of the paper Camp considers the factors of particle-settling velocities; nature of the settling process; settling analysis of suspensions; clarification for an ideal basin; bedload movement; effects of turbulence; flocculent suspension; overflow rate, detention time, velocity, and tank dimensions; and shortcircuiting and stability. He concludes with a possible future design of a tray-type settling tank. Camp's principal arguments in this paper, as in earlier papers, are for the adoption of overflow rate as the most important design criterion, with adequate consideration for the variations in settleability of the suspension. He shows that it is perfectly possible to determine, with a simple graphical integration of the settling-analysis curve, what removal can be expected of an ideal separator which operates at a certain overflow rate. The removal actually obtained in a separator gives a measure of the effectiveness at a certain flow or overflow rate. The ratio of the actual to the theoretical removal is then a real measure of performance, regardless of overflow rate or other variable. This performance may be better than 100 percent under some conditions because separators can produce, and have produced, removals better than those for ideal tanks, especially over short lengths of tank. Detention time, velocity, and tank dimensions all exert secondary effects on performance.

In discussing Camp's paper, Eliassen[23] takes issue with Camp for stressing overflow rate as the governing criterion and then saying that shortcircuiting can seriously affect the performance. Imagine a tank, he suggests, in which the flow is uniform and ideal in every respect, but through the top one-third of the tank only (Figure 8). Inasmuch as the surface area is unchanged from what it would be with the full tank volume active, the overflow rate would be unchanged. The average detention time, however, would be reduced to 33 per cent of the theoretical — indicating severe shortcircuiting and, by inference, a poor settling tank. However, inasmuch as a particle is settled out as soon as it falls one-third of the depth and reaches the stagnant region, Eliassen asks, why is it not conceivable that this tank with the very unsatisfactory hydraulic charactristics would be as satisfactory as, if not better than, a settling tank with all the volume active, with the possibility of scouring sediment which has settled to the bottom? (See also Hazen[26] in this regard.) Camp counters with the statement, pointed out by Stein[71] (one of the other discussers), that overflow rate, although it is ordinarily defined as discharge per unit surface area, can also be shown to equal depth divided by detention time. In this form it is easy to see that, for a given tank depth, shortcircuiting which cuts the detention time affects the overflow rate in exactly the same proportion. He observes further that almost all improvements to the inlet structure and to the baffling of sedimentation basins result in increased removal of suspended solids. Inasmuch as the overflow rate is not affected by the change, the improved removal must be caused by reduced shortcircuiting.

H) On the Separation of Particles Lighter than Water

The first paper to devote special attention to particles which separate by rising rather than by falling was delivered by Hart[30] at a meeting of the API in 1938. He made the fundamental observation that the oil-water separation problem is essentially the same as that of municipal water purification by sedimentation. In this first paper, Hart entered the important controversy of inlet weirs vs. baffles for providing flow distribution. He expressed the belief that baffles, if carefully controlled, would probably be superior; but that, for ordinary cases of operation, a sharp-crested weir will provide the best over-all efficiency. He reported the results of tests on a model separator which had a settling section 12 feet long by 8 feet wide by 3½ feet deep (Figure 9). The model was provided with a reversed-flow inlet weir, and gave satisfactory separation efficiencies for overflow rates up to 0.4 fpm. In scaling from the model to prototype sizes, Hart employed the Froude law exclusively.

Oil-Water Separator Design

Following World War II, Hart published an extensive series of articles on refinery waste disposal, of which four dealt with the design of oil-water separators. These articles appear to have been the basis of the separator design currently recommended by the API. In the first article[31] of this group, Hart explains that the Reynolds number (based on the hydraulic radius of the transverse section) is the fundamental criterion of turbulence in the separator. Using some empirical data

from a separator model test, he establishes a relation between gravity of oil particle and allowable Reynolds number—showing that the latter must decrease as the gravity of the oil to be separated approaches that of the carriage water. This relation determines the capacity of a separator of "standard" cross-section (governed more or less by practical considerations). The particle size and rate of rise do not enter into this relation; only the specific gravity.

Interestingly Hart places considerable significance on the application of certain features of open-channel hydraulics to the separator problem. He speaks of the desirability of having the width as nearly as possible equal to twice the depth. This stems from the "most efficient rectangular section" for open channels, and refers to long channels in uniform flow—something which is not ordinarily approached in a separating chamber. Again, he refers to the "critical depth at which turbulence would become excessive." This critical depth is the well-understood depth which carries a given flow with a minimum specific energy, and has nothing directly to do with the turbulence. He introduces serious error, the writer believes, when he reasons that subcritical flow will, by definition, be flow with low turbulence.

Hart makes a strong argument in favor of a weir inlet to a basin. The turbulence in the approach channel is stilled upstream from the weir. In addition, the weir brings the waste flow into a relatively thin layer—permitting a leveling of any large temperature and gravity differences which might bring about thermal currents or stratification in the sedimentation basin which follows.

In the next article[52] Hart shows that the length of the primary sedimentation basin is fixed by the rate of rise of the oil globule to be separated. With the discharge and cross-section previously fixed, this is seen to be a proper adherence to the overflow-rate theory. He also states that the oil-retention baffle should not extend farther than one-half the flow depth, as this would cause the outlet-end effect to be influential too far forward in the sedimentation basin. Hart next takes up the design of the secondary basin[53] which is to effect final cleanup of the waste water. Allowing for some shortcircuiting, he arbitrarily makes the secondary basin 40 percent longer than the primary. He proposes an ingenious oil-retention baffle with the curve of an ellipse (Figure 10). The water which strikes the baffle from any reasonable angle is deflected upward. The oil particles which rise in the water are even more strongly deflected upward.

In the last article,[54] Hart discusses the all-important problem of the so-called stable emulsions, where the water is in the continuous phase and the oil is in the dispersed phase. These emulsions must be broken by special treatment before they are amenable to gravity separation, and such is beyond the scope of this review. Hart also points out that suspended solids in waste water can reduce substantially the effectiveness of a separator by carrying some oil through the separator on particles which neither settle nor rise, and by trapping large quantities of oil in the bottom slurry.

The API Manuals

The first attempt on the part of the API to recommend a design for an oil-water separator came in 1930, with the publication of the first *Manual on Disposal of Refinery Wastes.*[51] The design is a simple rectangular basin, divided into five pockets in which the separation takes place. The manual suggests only a few general design figures, viz., average velocity not to exceed 2 feet per minute; detention time to be not less than 60 minutes. Considerable stress is placed on having low velocities through the partitions between the pockets, as high partition velocities cause eddy currents detrimental to effective separation. In this, the early manual proved to be entirely correct. It also recommended no use of separator baffles because they, too, cause eddy currents—a point of much discussion today. The inlet box employed a contracted weir, but the flow was further distributed under a partition before it entered the first pocket.

The next edition[52] of the API manual, in 1933, added improved mechanical devices, but did not change the fundamental design of the separator.

The third edition,[53] in 1941, made an about-face from the old pocket-style separator to a new design based on the aforementioned articles by W. B. Hart, i.e., a separator with a primary and a secondary basin. The inlet to both primary and secondary basins was a reversed-flow free-fall weir followed by a film-rupture tray, the purpose of which was to break up blobs of oil and sediment which would otherwise be carried through the separator with the water. The oil-retention baffle in the primary basin was straight, with a slight forward curve at the bottom; whereas that in the secondary basin employed the elliptic forward curve with a semicircular reverse curve at the bottom.

The most recent edition[54] of the API manual (1949) makes only a few changes in the separator design. A quadrant fillet of radius equal to half the water depth has been added to both ends of both basins. This is currently thought to be of some significance in connection with shortcircuiting. Also the elliptic oil-retention baffle has replaced the straight baffle in the primary basin.

Performance of Refinery Waste-Water Separators

In a recent paper Giles[58a] gives a comprehensive picture of the operation of the largest installation of the API gravity-type oil-water separators described above. This installation, at Whiting, Ind., comprises 34 two-stage units and has a design capacity of 110 million gallons per day. The separators recover substantial amounts of oil but at a cost of about 50 percent in excess of the cost of crude oil, so the installation must be justified on the basis of improving the quality of the refinery effluent discharged to Lake Michigan.

Giles lists three factors limiting the effectiveness of a separator, all bearing on the condition of the influent waste water: 1) mixtures of solids and oil having specific gravity almost the same as the carriage water; 2) emulsions, particularly of the oil-in-water type; and 3) excessive quantities of settleable solids. These factors actually limit the performance of an *ideal* separator and they account for about half the oil found in the effluent of the API separators. The other half can be charged to "non-ideal settling conditions" such as imperfect hydraulic characteristics (shortcircuiting), convection currents, turbulence, operation of flight cleaners, or exceedingly small size of the dispersed oil droplets. In discussing this paper, Rohlich[58b] states that the non-ideal settling conditions could be improved by eliminating any type of overflow weir at the inlet, and substituting in its place a slotted baffle, obstructing 93 to 97 percent of the free area (see Section F above, "Inlets and Outlets").

The importance of eliminating the inlet weir is demonstrated in some tests reported by Weston.[58a] The second-stage inlet device of an API separator, involving the reversed-flow weir, was replaced with streamlined vertical guide vanes, and the removal rate of the separator was improved by an average of 15 percent or more. Weston offers a practical field test to determine what fraction of the oil in the influent may be considered non-separable. In this STS (susceptibility to separation) test, a gallon sample of the influent liquor is allowed to settle for a period equal to the detention time

in the tank. The oil then remaining in suspension is called the STS value and represents the ppm. of the oil not amenable to separation in a gravity separator of practical size. Weston then claims that the true measure of a separator's efficiency is the percentage reduction in separable oil which it achieves. This is a step in the right direction, but it is not so concise as Camp's[11] scheme of determining the distribution of settling velocities and thereby a theoretical removal rate for any given overflow rate, then defining separator efficiency as the ratio of actual to theoretical removal rates.

Hill[26a] offers some information on the important subject of breaking emulsions before they reach the separator. He states that the customary method of breaking the more important oil-in-water emulsion is to acidify slightly and to coagulate by addition of aluminum or calcium salts. The water-in-oil emulsion (from tank bottoms or crude tanks) can generally be broken by simple heating, by adding a hydrophilic colloid, or by electrical means.

Aids to Gravity Separation

In recent years a number of schemes have been advanced to improve the separation obtainable from straight gravity differential. All such schemes necessarily involve increased capital and operating costs of mechanical and/or chemical equipment. However, these frequently appear to be more than offset by the saving in capital investment in separating basins. One scheme which currently holds considerable hope for success is that of getting air dissolved or entrained in the influent waste water. The rising bubbles then carry the more sluggish particles of oil and grease to the surface. This approach to the problem was originally applied to paper-mill wastes. Gibbs,[25] describing a "unique flotation unit for industrial waste treatment," states that a removal of 96 percent was obtained in the waste from a soap factory by the introduction of air bubbles at the rate of 5.5 cubic feet per minute under 13 inches of vacuum. The overflow rate was 0.4 foot per minute, and the total flow was 660 gallons per minute. Gibbs found that the air bubbles must be smaller than the smallest suspended particle if they are to be effective in aiding removal.

Ashley[3] describes surprisingly satisfactory results from a small separator which was installed at the site of a West Coast tank-car washing plant (see page 106). In this case the influent is dosed with aluminum sulfate and activated silica, and is then saturated with air at a pressure of 25 to 40 psi. for 2 or 3 minutes before its entrance to the separator, in which the overflow rate is about 0.35 foot per minute. A high-density suspensoid floc forms as the dissolved air comes out of solution, and the individual flocs are carried to the surface by the tiny air bubbles.

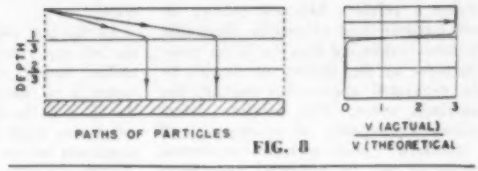

Figure 8. "Harmless" Shortcircuiting in a Settling Tank (after Eliassen[25]).

FIG. 8

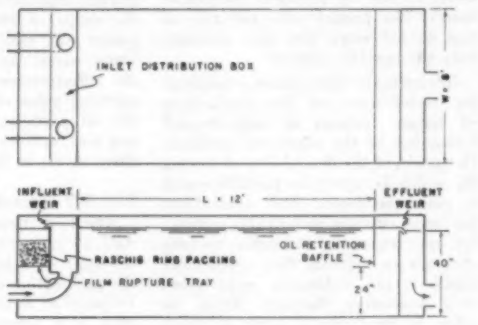

Figure 9. The First Model Oil-Water Separator (after Hart[27]).

Summary

An attempt has been made in the foregoing pages to review the known literature on the subject of gravity separation in artificially constructed basins—especially the separation of oil-water mixtures, including the necessary background on the separation phenomenon proper. It is seen that there have been proponents for almost every conceivable facet to the theory of sedimentation. Most of the questions have been settled through the years of practice and reflection, but there remain two important points of separator design which continue to be moot questions. One of these concerns the relative efficacy of the overflow weir vs. the baffled inlet; the other relates to the possible virtue of shortcircuiting in a deep basin where a particle can be considered separated if it reaches the quiescent region adjacent to the shortcircuiting region of the main flow. These questions are the subject of current experimental study and perhaps will be solved one way or the other in the near future.

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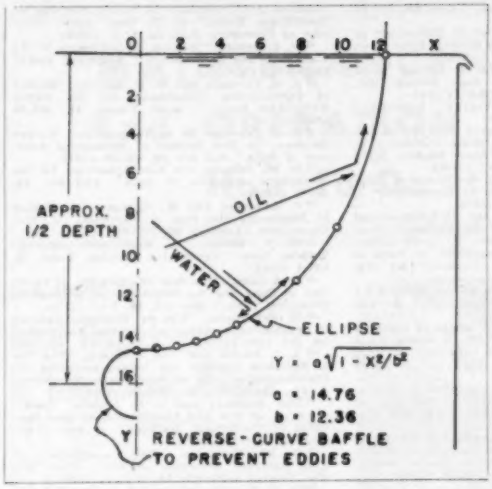

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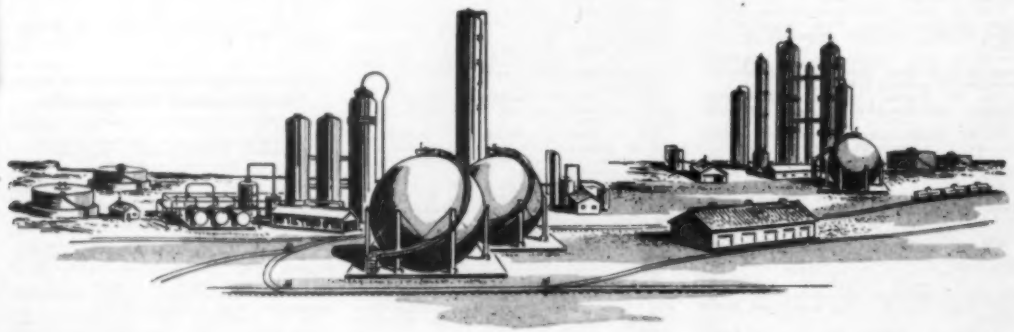


MAINTENANCE And OPERATION How To Do It—

THE HOW OF—

Good Housekeeping In Compressor Rooms

"GOOD housekeeping" is generally acclaimed as desirable in process plant operations. In practice, however, the term receives variable interpretations. In some plants the operators will settle for the removal of the larger pieces of litter resulting from construction or maintenance work, and in other plants floors and equipment are maintained at a mirror polish.

The optimum level of process unit appearance is a matter of economics, but so many factors enter into the problem that no easy answer is available. More and more plants seem to follow the reasoning that complete cleanliness for their equipment and facilities is not too difficult to attain and that it probably pays its way in terms of maintenance and inspection time saved and in better plant operation. Certainly the operators seem to work at a higher level of efficiency in a clean plant.

The engine rooms of Ohio Oil Company's South Coles Levee plant near Taft, Calif., are excellent examples of the mirror-bright school of good housekeeping. Floors are polished and oil and water leaks are conspicuous by their absence. This good appearance is maintained by carefully planned procedures that are closely followed by plant operators and maintenance men and that have the full support of plant management.

A line of Gas Engine Driven Compressors in Coles Levee Plant. Note neat appearance of floor—no oil or water leaks.

Starting point of the good housekeeping program at the Coles Levee plant is the good design and well finished construction of the installations. Floors and foundations have been smoothly finished and given surface coatings impervious to scratches and heel markings, to water, oils, and gasolines. They are subjected to daily polishing and are kept well waxed. Process equipment, the pumps, compressors, generating units, and so on, are painted with a tough enamel and are kept scrupulously clean by the application of clean wiping rags.

Defective gaskets and improperly fitted connections are perhaps the most

Foundation and Bedplate of a Compressor with no Leaks or Indications of Recent Spills of Oil. Lube oil filling system is at end of crankcase.

Lean Oil Pumps in Ohio Oil Company's Coles Levee Plant. The first pump had just been repaired by changing crank-bearing shells.

prevalent offenders in this matter of good housekeeping. At this plant leaks are repaired at the first possible opportunity. Where repairs require the stopping of equipment, this is done as operating requirements permit. Gaskets are installed with liquid sealer that helps prevent leaks, and machinery bolting is uniformly tightened with torque wrenches.

For maintenance work not requiring the movement of heavy equipment, drop cloths are spread over floors. Where heavy parts must be moved, planking is spread over the drop cloths to prevent damage to floors and foundations.

Operating conveniences have been provided that have considerable bearing on the manner in which this equipment is maintained—they free the operators from some of the usual time-consuming routine chores of plant care. A typical example is the system used to supply lubricating oils to the engines. At each engine a special connection is used to feed lube oil into the crankcase as required. The operators open a plug valve at the engine and then "trigger" a spring loaded "whistle valve" to bring the crankcase oil level to the desired point as indicated on the gauge glass at the end of the engine. This system besides saving time in filling the engine crankcases also avoids oil spills and thus saves in clean-up time too.

HOW TO PROTECT

Fuel Gas System Against Liquid Flooding

THE vessel shown in Figure 1 operates as a scrubber on fuel used by internal combustion engines, the boilers, and the circulating oil furnaces of a natural gasoline plant. As with most type gasoline plants, this fuel supply comes from the reabsorber residue gas. To prevent absorption oil from getting into the fuel system, the scrubber is equipped with an internal ball float which positions a dump valve. The dump valve is normally in the closed position.

Whenever the liquid level starts building up in the scrubber, the valve will open and discharge the liquid to a rerun tank. Opening of the valve also causes a whistle to blow, thereby warning the operator that an abnormal condition exists. Without prompt attention a serious loss of absorption oil could result.

In the event that the ball float does not function properly, a second level control is set to operate at a level one foot above the operating level of the ball float. The operation of this snap-acting level control is to shut off the flow of lean oil to the reabsorber which it does by bleeding the air from the diaphragm of an air-to-open motor valve (Figure 2) which controls the lean oil flow to the Reabsorber. Whenever this happens the flow controller instrument tends to increase its output air pressure to a full 17 pounds in order to bring the oil flow rate back to the set point on the controller. To prevent this a small orifice is placed in the air line between the flow controller and the control valve diaphragm so that the diaphragm pressure will be zero pounds so long as the level control is operating. As soon as the level drops, the bleed orifice is closed and the pressure builds up on the diaphragm as required by the setting on the instrument. The small orifice does not interfere in any way with normal operation of the control valve.

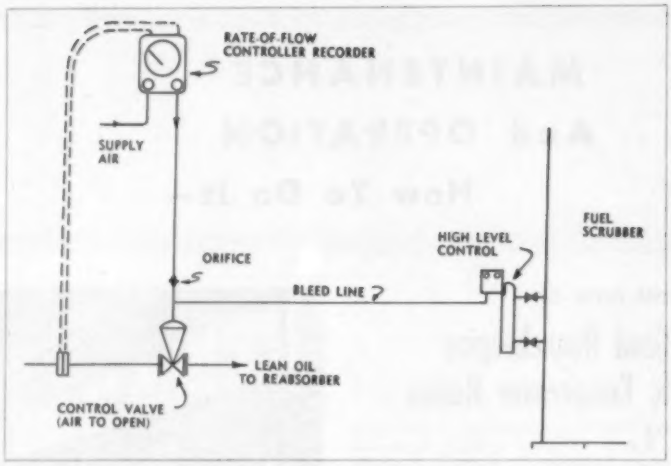


Diagram of Fuel Gas System Showing Protection Plan

Figure 1

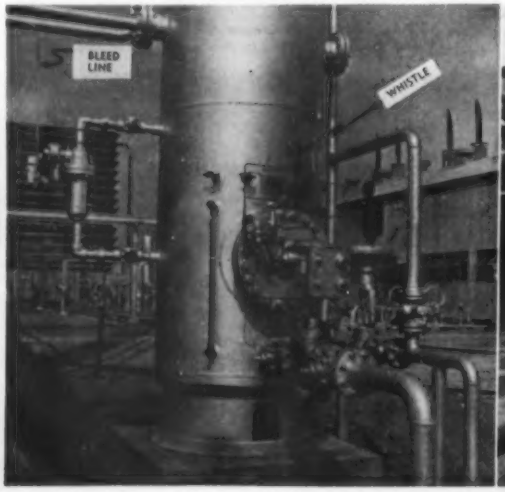


Figure 2

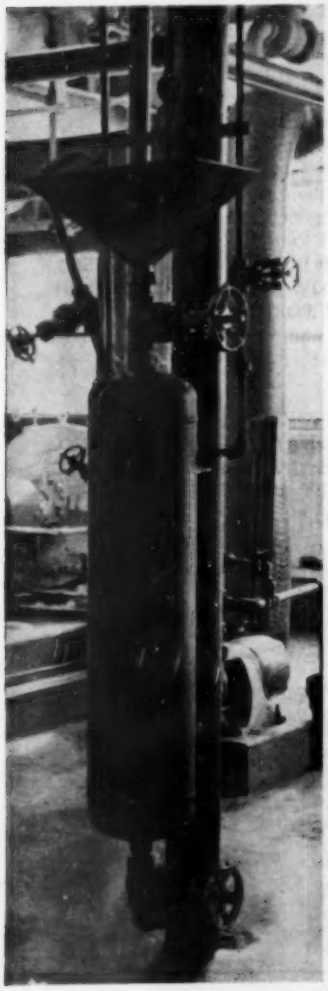
HOW TO—

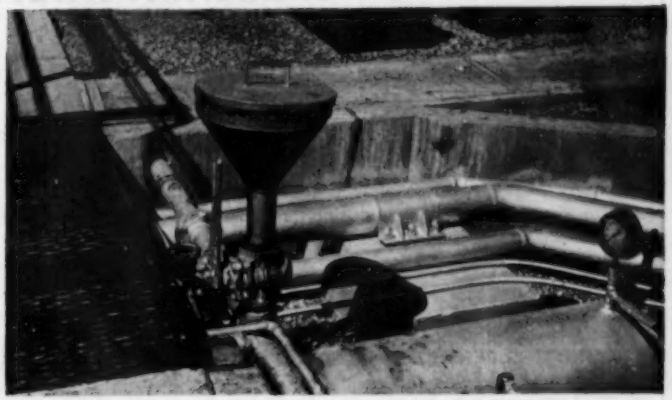
Mix Chemicals For Water Treating

MIXING chemicals for boiler water treating is a comparatively simple task that often is messily conducted, the result being both a wastage of chemicals and waste of the operator's time.

In the gasoline plant of Panoma Corporation, near Amarillo, Texas, a neat arrangement has been worked out for the mixing of water treating chemicals.

The chemicals are loaded into a hopper at the top of a small closed vessel. An outlet valve at the lower end of the vessel is shut. Hot water is put into the hopper through a specially provided line, and the resulting solution of chemicals in water emptied into the vessel by opening a valve under the hopper. The vessel is filled with water. The chemicals are carefully measured to provide a standard solution in the full vessel. This solution is available for feeding into plant boilers at metered rates along with the raw boiler feed water.





HOW TO—

Handle Engine Crankcase Drainings

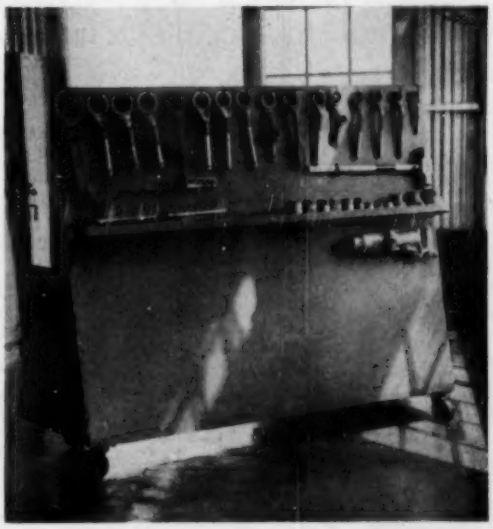
A BLOWCASE is provided at one gasoline plant to handle crankcase drainings in a convenient and neat manner. The blowcase is a horizontal vessel made of a section of large pipe. It is located near the engine room and fitted with piping to apply air pressure and lines that discharge the oil to final disposition. A large funnel is provided over the blowcase so containers of waste oil can be poured easily without spills. A heavy sheet metal cover prevents sand, dust and litter from clogging the equipment.

A similar blowcase is provided for fresh lubricating oil in another part of the plant yard convenient to trucks. It has a larger funnel and situated so full drums of oil can be poured without spills. The fresh oil blowcase is connected with piping for air pressure, and leads to an elevated storage tank which supplies adequate head for filling lubricators and crankcases without using buckets or measuring cans.

HOW TO—

Make Handy Tool Wagon

ONE more tool rack has been worked out by a plant maintenance group. It is made of sheet metal and mounted on ball bearing rubber-tired casters. The board and storage section is of wedge shape and each side is provided with hooks for wrenches and other tools. A convenient tray is just below the row of tools. Cabinets with doors at each end serve the heavier tools that cannot conveniently be hung on hooks. The tool board and case can be pushed easily to any part of the building without damaging the floors.



"OPERATION SAFETY"

W. A. SULLENDER
Pan American Refining Corporation, Texas City, Texas

Towers:

A very important safety practice that should be observed at all times is that of cutting steam into towers that are closed during the shutdown of a unit. This will be reviewed from the three methods used in handling towers during a shutdown:

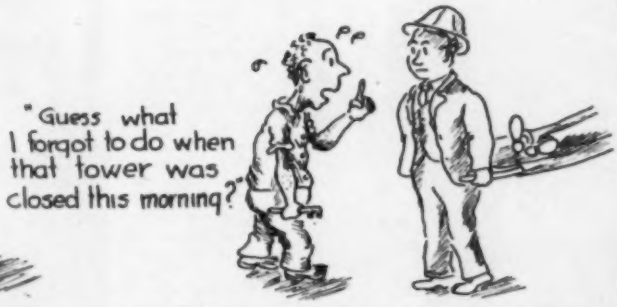
I. When oil levels are left in the towers with a normal gas blanket the work in the unit will not be extensive and no welding or hot work will be done. No steam is required in the towers.

II. When the towers are depressured, pumped out, and steamed, the system is being made safe for welding or hot work. In this case **KEEP A SHOW OF STEAM AT THE VENT OF THE TOWER UNTIL IT IS READY FOR INITIAL OPERATIONS.** The continuous supply of steam to the tower prevents it from cooling and pulling in air which may form an explosive mixture with hydrocarbons present in tray deposits, level controller connections, etc.

III. Usually the towers are depressured, pumped out, steamed thoroughly to remove hydrocarbon vapors and light material and then water washed to float all hydrocarbons overhead to the reflux drum so the tower may be entered. As soon as the towers have been opened, a steam jet should be placed at the top manway to pull large volumes of air through the tower to ventilate it. **AS SOON AS THE TOWER IS CLOSED, CUT IN STEAM AND KEEP A SHOW OF STEAM AT THE VENT UNTIL THE TOWER IS READY FOR INITIAL OPERATIONS.** This prevents the closed tower from generating an explosive mixture by vaporizing hydrocarbons from tray packing, deposits, etc.

IV. In general, **ALWAYS AVOID** the undesirable position of having **A CLOSED VESSEL CONTAINING AIR AND HYDROCARBONS** because the mixture **MAY REACH EXPLOSIVE LIMITS** and **MAY BE IGNITED BY IRON SULFIDE DEPOSITS** which, as you know, become ignited by contact with air.

Because—If You Don't—



Reducing Water Pollution For Oil Refineries

WILLIAM H. REDLIEN, JR. AND JOHN H. McCLINTOCK
Esso Standard Oil Company

ONE OF THE many acute problems facing the management of a petroleum refinery today is to conduct his business in such a manner that it will not constitute a nuisance to his neighbors in his community. This is not a new problem, but with increased demands being placed on the water resources of our nation, and with increases in the industrialization and population concentrations of certain areas, the problem is becoming more and more acute and is requiring more and more managerial and technical consideration.

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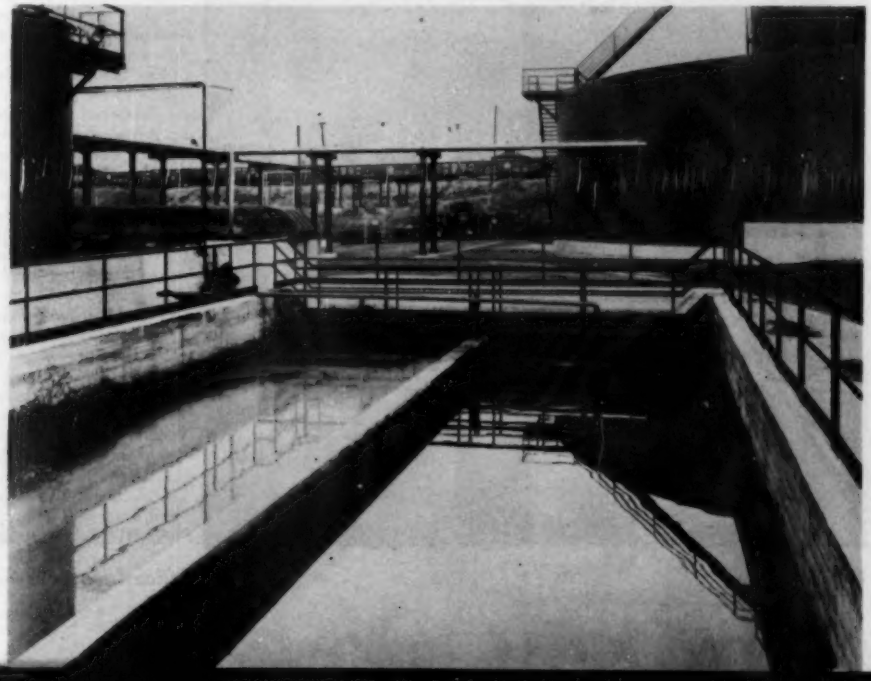
ONE of the chief facets of the over-all nuisance problem is the abatement and control of water-borne wastes. Affiliates of Standard Oil Company (New Jersey) have been concerned in developing new and improved methods for disposing of such wastes for many years, and articles have been published in the trade press describing projects such as the silt and emulsion treating plant at Esso's Baton Rouge refinery,[7] and the vacuum precoat filtration of slop emulsions at Humble Oil & Refining Company's Baytown refinery.[2]

Other projects have also been under investigation by Jersey Standard's affiliates, but have been adequately covered by articles from other organizations. Thus, information has been furnished on flue gas neutralization of spent caustic[1] and chemical treatment of waste streams.[6] This article is designed to supplement information previously published and enlarge the background required for an intelligent approach to the involved problem of pollution which exists at any refinery.

The first step which any oil refiner must take is to remove free oil from the effluent waste water stream. Most refineries provide some type of gravity separation to remove the bulk of the oil. The efficiency of this method of oil removal is greatly impaired if emulsions or finely divided solids are permitted to enter the system. The extremely small oil globules of oil-in-water emulsions rise so slowly that they are not susceptible to gravity separation except with excessive and prolonged settling time, while any solid or semi-solid matter with a density greater than that of water can become coated with oil, forming particles which neither sink nor rise. Once these particles become diluted in the refinery effluent, their removal is extremely costly due to the required handling of large volumes of water. Chemical flocculation has been successfully used for final clarification of separator effluent[3, 4, 5, 6] and air flotation of the suspended solids and oil, a comparatively inexpensive process, has



Separator for Gravity Removal of Oil from Waste Water.

shown some indication of success. Development work is planned on this latter process. In view of the expense involved in final clarification, however, an attempt has been made to determine the nature of the solids with the hope that they could be eliminated at their sources. The solids include: sanitary sewage, tank cleanings and water drawoffs, coke and heavy tars, organic growths in sewers and separators, silt in surface drainage, precipitated solids, and cracking catalyst.

Sanitary sewage without treatment is a pollutant in itself. Many refineries have provided means for its segregation and treatment, either individually or through a cooperative venture with adjacent communities. The Esso Refinery at Everett, Mass., for example, has segregated sanitary sewage for disposal into the municipal treating plant, while Esso's Baltimore refinery has area septic tanks with chlorination facilities on a more recent installation. Humble Oil & Refining Company's Baytown refinery has recently completed a segregated sewer system and treating plant. In each case, effluent improvement was obtained not only through a reduction of coliform bacteria, but also by removal of potentially oil-bearing solids.

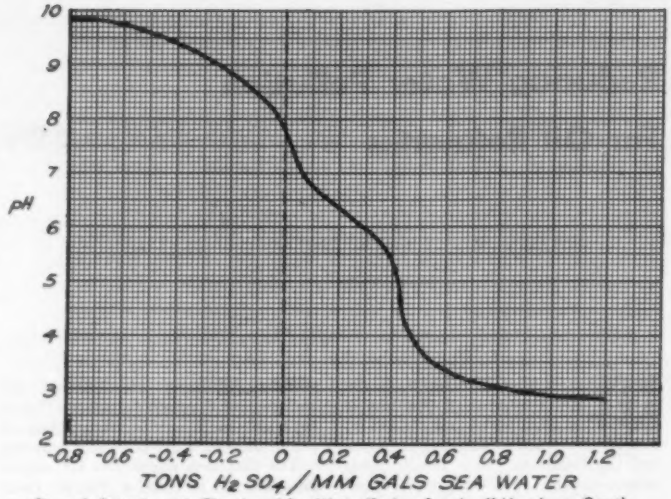


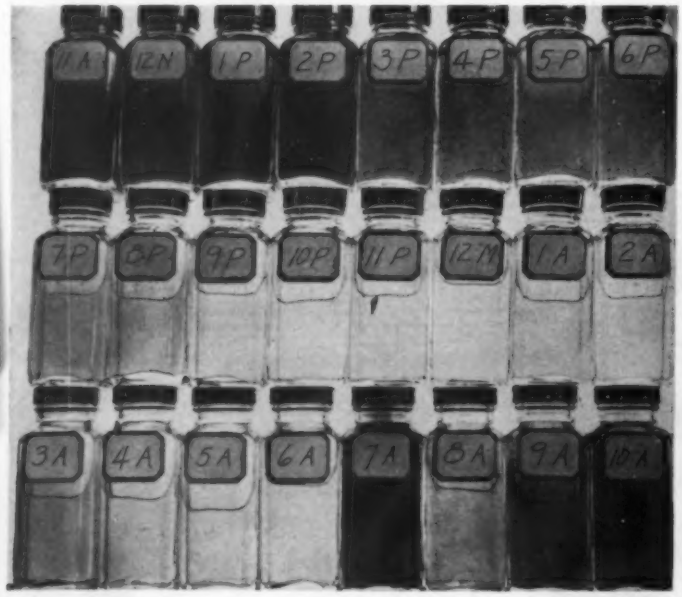
Figure 1. Potentiometric Titration of Sea Water (Surface Sample off New Jersey Coast).

Humble's Baytown Refinery has reported some difficulty in the operation of their sewage treating plant due to the high oil content of the incoming stream. This required that the trickling filters be by-passed to prevent destruction of the bacteriological activity of the bed. Some slight success was associated with the use of a modified oil well cementing technique in which the sewer was filled with a thin slurry of special slow-setting cement under sufficient pressure to force the cement out through cracks in the tile sewer joints. This experience emphasized the importance of constructing a tight sanitary sewer system with complete exclusion of all oil sources, not forgetting minor sources such as laboratory discards.

Biological growths in separators and sewers have complicated the separation of oils, especially at Esso's Bayonne refinery. The gray-colored matter experienced there, which has been identified as zoogleal masses, a type of capsulated bacteria, has accumulated to growths more than a foot in length. The bacteria, each cell of which is surrounded by gelatinous matter, readily absorb a comparatively large quantity of oil which is carried through the separator into the receiving waters when the growths slough off. An oil slick forms whenever agitation causes the material to surface.

A cooperative study carried out by Esso's Bayonne refinery with the help of Dr. Willem Rudolfs of Rutgers University, and the State University of New Jersey, was directed toward determining the essential requirements for growth of the organism and the most effective method of destroying it. Laboratory studies of bactericides (naphthenic acid, sodium hypochlorite, copper sulfate), indicated that hypochlorite was, by far, the most effective, requiring a 15-minute residual of only 0.1 ppm to destroy the growth. The chlorine demand of the separator influent is generally less than 30 ppm. Copper sulfate in concentrations of up to 2.5 ppm apparently accelerated growths of the organism and doses as high as 10 ppm were not entirely effective in controlling growth

Figure 2. Samples of an effluent were taken hourly during a 24-hour period from a Northern refinery. Note effect of finely suspended solids on conditions of the effluent; the darker samples, in general, also contained more oil.



and could produce toxic effects in receiving waters.

The separator growths are temporarily eliminated by extreme shock chlorination accomplished by dumping a solution of sodium hypochlorite into the separator influent. Shock chlorination is presently being done at seven-day intervals. Two six-inch excelsior filters inserted in series at the end of the effluent ditch successfully removed the major portion of growth sloughed off by the chemical treatment. The filters, which require repacking every week or two, have a capacity of about 20 gallons per minute per square foot for a two-inch head loss.

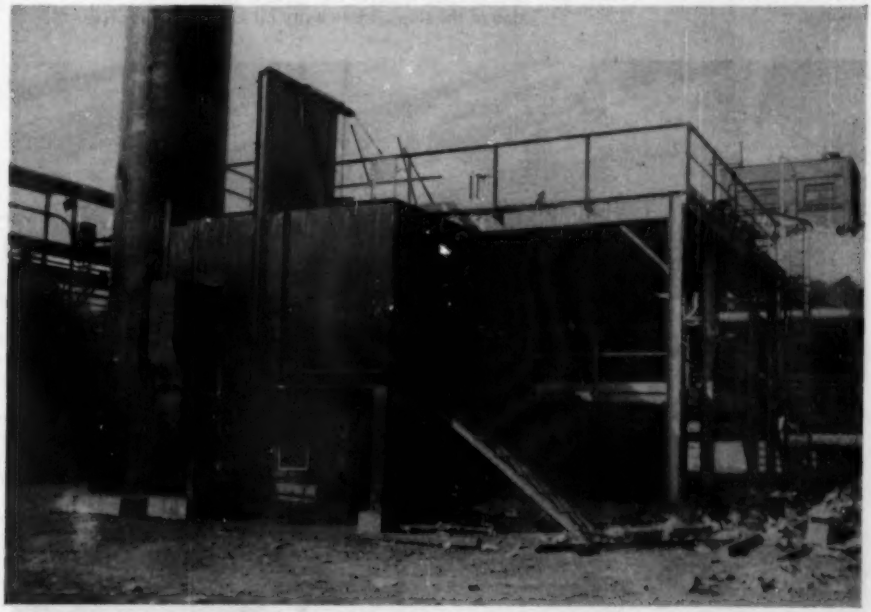
In addition to biological solids originating from sanitary sewage and bacteriological growths, mineral solids are also responsible for poor operation of the conventional gravity separators. For this reason, facilities should be provided at the process units to recover the heavy tars and coke and to prevent the discard of solid materials such as cracking catalyst and filter clay to the sewer. Tank cleanings which are thoroughly saturated with oil should be segregated for emulsion treatment or disposal, while proper grading and stabilization of dirt embankments combined with adequate cleaning of catch basins will minimize silt carryover to the separators.

Solids, although segregated, still present a disposal problem since they are generally saturated with oil. Incinerators have been used to reduce the waste to a desirable dry fill, and Humble Oil & Refining Company is experimenting with the use of a vacuum precoat filter for recovering the oil from the solids and producing a cake satisfactory for dumping. Esso's Baton Rouge refinery is especially troubled with oil-bearing solids due to the use of silt-laden Mississippi River water for cooling. The oil-soaked material which collects in the separators, as well as solids from tank cleaning is washed in the silt treating plant with hot water and air agitation. The oil is recovered for reprocessing, while the silt which bleaches to the color of a riverbank deposit is used as fill.[7]

Solids can also be formed in the sewer separator system through the interaction of chemical wastes. Thus, iron sulfide is formed when sulfide-bearing distillate drum water contacts iron-bearing wastes; magnesium and other metallic hydroxides are precipitated when caustic wastes contact waste waters, especially salt water; and sulfur is a product of the reaction between H_2S and SO_2, the oxidation of sulfides and the acidification of thiosulfates.

Besides contributing to the solids in the separator system, sulfide-bearing waste waters and spent caustic also appreciably increase the chemical oxygen demand and odor of a refinery effluent. The spent caustic is especially objectionable since, when discharged to salt water, a magnesium hydroxide floc is formed simultaneously with the release of the oil which tends to prevent surfacing of the oil within refinery limits. In some cases, the discard of spent soda can be minimized by recirculating after steam regeneration. This has been practiced for many years where the economics justify such a process. The recirculated soda becomes unregenerable in time, and a large discard rate is necessary. To prevent an odor problem and oil pollution of the effluent, the odoriferous oils and sulfide must be removed from the soda before discard. In general, this requires acidification and settling.

As previously mentioned, carbon dioxide in flue gas has been used to neutralize the caustic with released vapors being stripped out by the large bulk of gas.[1] This principle is also being applied to sulfide-bearing distillate-drum water at a new refinery constructed at Fawley, England. Esso's Everett refinery is experimenting with a continuous acidification of spent caustic with unseparated acid sludge, thereby eliminating two potential sources of pollution. In neutralizing any soda previously used to remove hydrogen sulfide or mercaptans, provision must be made to handle the gases which are generated upon acidification. Burning in a furnace is an adequate means of destroying these materials. Caustic emulsion formed in treating of wax and lube oils which do not contain either of these obnoxious gases have been effectively resolved by combining with acid water



Incinerator for Disposal of Combustible Refinery Wastes.

from the same area and settling; additional acid must occasionally be applied to insure a complete break.

The disposal of acid waste presents another problem for the pollution engineer. An effluent pH above 4.0 should be maintained to prevent excessive corrosion of downstream concrete construction and a pH above 5.5 has been recommended to avoid effect on marine life. Generally a pH range of 5.5 to 8.5 is acceptable. All natural waters will tolerate a measurable addition of acid due to the buffer action of dissolved salts. In sea water this is especially true, as shown in Figure 1, giving the titration of surface samples taken off the New Jersey coast. The buffer effect will, of course, be less for the brackish water used in most coastal refineries, but, in view of the large cooling water requirements of a refinery, the effluent can safely handle a limited tonnage of waste acid provided it is added at a steady rate and contains no excessive quantities of chemicals or oils. No precipitate is formed at lower pH, but at pH above 9.5 a floc of magnesium hydroxide forms in seawater. Thus, only acidic water should be added to seawater since a floc will form when adding even a small amount of caustic due to local concentrations before thorough mixing.

The treatment of slop oil emulsions has also presented a difficult problem which is still under study. Emulsions which are skimmed from the surface of separators and drawn for treatment as wet bottoms from tanks do not contribute to pollution of refinery effluent as such, but in their treatment, water and solids must necessarily be removed. The solids are returned to the separator and form additional slop emulsions, as well as contribute to oil pollution of the effluent. Methods were, therefore, investigated for resolving the slop emulsions into oil satisfactory for refractionation, water which could be returned to the separator with no ill effects, and sludge which could be safely dumped or incinerated.

Vacuum precoat filtration and centrifuging have both been considered. The former has been reported in previous articles,[2] while centrifuging has proved successful in full-scale tests of limited duration. Two types of centrifuges were required; one provided for continuous solids slurry discharge through peripheral nozzles with separate outlets for clarified water and oil, while the other, a solid bowl type with internal screw conveyer, concentrated the slurry to a sludge containing about equal portions of oil, water and solids which would be satisfactory for incineration. Further development work is required, however, before the process can be recommended for general use.

The present slop emulsion treating method consisting of heat, chemicals and settling resolves the greatest portion of the slop oil into a dry oil satisfactory for refractionation. However, an interfacial, solids-stabilized emulsion remains which does not respond to the treatment. Recent tests have shown that this emulsion can often be resolved by diluting with an equal volume of previously "dried" slop oil. It is believed that the added oil increases the solubility of any organic emulsion-stabilizing materials.

Complex Problem

The pollution problem as encountered by the refinery engineer is complex and requires extensive study in order to devise an adequate system which is not excessively expensive in either investment or operating costs. Even though many of the problems can be solved through the use of conventional processes, the choice of the optimum method and the solution of problems peculiar to the refining industry are dependent upon a thorough knowledge of the pollution problem as it exists in the refinery. Free exchange of technical information which will provide the pollution engineer with miscellaneous, but pertinent, facts, as well as developed processes, will speed the development of the required pollution abatement programs.

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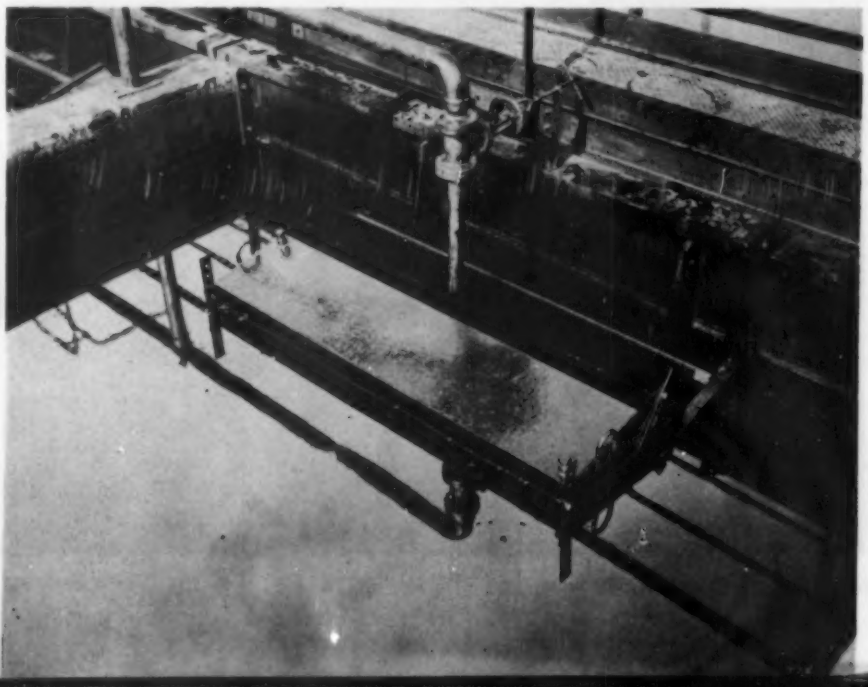

Close-Up of Self-Adjusting Floating Oil Skimmer in Waste Water Separator.

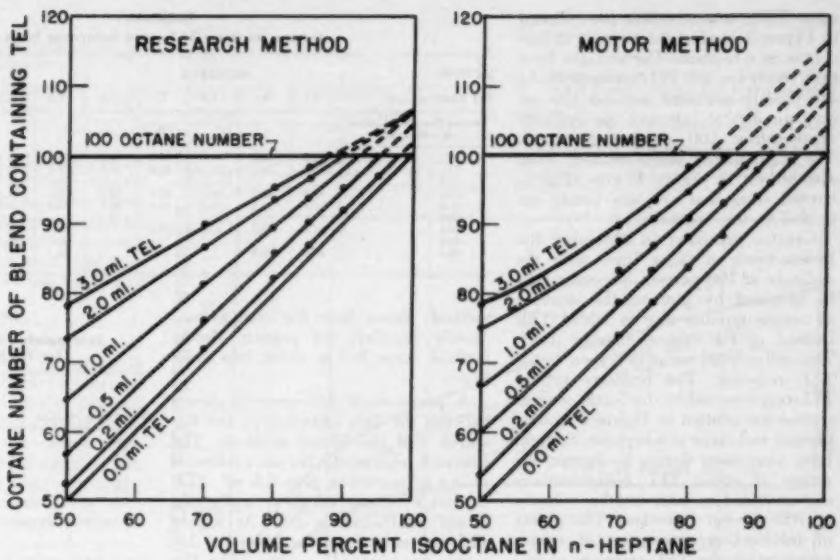

Figure 1. Octane Numbers of Reference Fuels Containing TEL.

Extrapolation of Octane Numbers Above 100

JOHN F. DETERS

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Whiting, Indiana

A NEW METHOD for extrapolating octane numbers above 100 has been developed for both the Research and the Motor methods, the extrapolated values being derived from octane numbers of blends of isooctane, n-heptane, and tetraethyl lead. Unlike previously published methods of extrapolation, this method uses only primary standard reference fuels. The extrapolation provides a conversion for antiknock ratings of isooctane plus TEL to octane numbers above 100 and these conversions provide a continuous measurement scale for data which fall partly above and partly below 100 octane number.

STUDIES of gasoline antiknock value become troublesome when experimental data fall both above and below 100 octane number. Ratings below 100 are expressed in terms of octane number, and those above are expressed as milliliters of tetraethyl lead in isooctane. A conveninet means of bridging this discontinuity would frequently be useful in gasoline blending studies.

The octane-number scale is an empirical but valuable measure of antiknock quality that has attained wide acceptance, primarily because of its simplicity. On this account, other scales[2] employing different reference fuels, or attempting to relate antiknock measurements more closely to fuel performance, have not been extensively applied to motor gasolines. The firmly established usage of the octane number scale suggests that a simple method of extrapolation to values above 100 would be desirable. Although methods have been published for converting Motor-method ratings of isooctane plus TEL to octane numbers[3,4] none has been presented for Research-method ratings. With the general shift in octane-number control of motor gasoline to the Research method and with production of commercial gasolines above 90 octane number, the need has developed for a conversion for the Research method.

Experimental

Octane numbers were determined on blends containing from 50 to 95 percent isooctane in n-heptane to which had been added from 0.2 to 3.0 ml. TEL per gallon. These values were obtained according to ASTM procedure by Research and Motor methods.[1] All blends were rated at least twice, and those between 95 and 100 octane number were rated as many as six times to establish each point firmly. In no case did the ratings for a blend cover a range greater than 1.0 octane number. The averages of these ratings are shown in Table 1.

Correlations

The Research octane numbers of isooctane-n-heptane blends at a con-

stant TEL concentration are plotted in Figure 1 against the percent of isooctane in n-heptane. The straight lines that result for all TEL concentrations are readily extended beyond 100 octane number to intersect the ordinate representing 100 percent isooctane. The equivalent Motor-method data, also shown in Figure 1, give slightly curved lines that are less firmly extended to the ordinate.

Greater precision in obtaining the intersections of these lines with the ordinate at 100 percent isooctane may be obtained by plotting the increase in octane number due to added TEL instead of the octane number itself. This differential value is known as the TEL response. The Research-method TEL-response values for each concentration are plotted in Figure 2 against percent isooctane in n-heptane. Straight lines have been drawn to connect all points of equal TEL concentrations and extended to intersect the ordinate at 100 percent isooctane. The points of intersection give a set of values representing the TEL response of isooctane. The TEL-response curves for the same blends rated by the Motor method are also plotted in Figure 2; in this case the extension is less reliable because the lines of constant TEL are curved.

When the TEL-response values obtained from Figure 2 are added to 100, extrapolated octane numbers for isooctane plus TEL are obtained. These are shown in Table 2 for both Research and Motor methods. From the plot of these values in Figure 3, the relation between antiknock ratings of isooctane plus TEL and extrapolated octane numbers can be read directly. The curve derived by Trimble and Richardson[4] for the Motor method, shown here for comparison, closely parallels the present Motor-method curve but is about two units lower.

TABLE 1
Octane Numbers of Leaded Reference Fuels

METHOD	RESEARCH					MOTOR				
TEL Added, ml./gal.	0.2	0.5	1.0	2.0	3.0	0.2	0.5	1.0	2.0	3.0
Volume Percent Isooctane in n-Heptane										
50.0	82.2	86.6	64.7	73.5	78.2	83.9	89.5	66.8	75.0	78.4
70.0	72.0	76.1	81.4	86.8	89.9	73.9	78.7	83.4	87.6	89.7
73.0	....	....	....	....	....	78.8	83.1	87.1	90.8	93.6
80.0	82.0	85.8	89.4	93.6	95.3	83.6	88.2	90.9	94.8	96.2
85.0	86.8	90.2	93.6	96.6	98.2	88.4	93.1	96.1	99.8	....
88.0	....	....	....	....	100.0	....	....	98.6	....	....
90.0	91.9	95.3	98.0	100.0	....	94.0	97.7	....	....	....
92.0	....	....	....	....	....	96.0	100.0	....	....	....
95.0	96.8	99.8	....	....	....	99.1	....	....	....	....

A pronounced difference is shown between the data obtained by the Research and the Motor methods. The Research equivalent for an antiknock rating of isooctane plus 0.5 ml. TEL is 104.5 octane number, while the Motor equivalent is 108. At higher TEL concentrations, the difference becomes progressively greater. The Research extrapolation ends at about 106.5 whereas the Motor extrapolation extends much higher. The fact that the Research method ends at this low level has been suspected from difficulties encountered in rating fuels higher than isooctane plus 0.5 ml. TEL. The extrapolated values obtained above verify this limitation of the method.

The present method of converting ratings above 100 to octane numbers is simpler than those previously used. Trimble and Richardson[4] employed a third hydrocarbon, benzene, as the means of changing from one scale to the other. Smittenberg[3] used an engine variable, compression ratio, as the intermediate step. The method presented here uses only a property that is directly involved—the TEL response of the primary reference fuels, isooctane and n-heptane.

TABLE 2
Extrapolated Octane Numbers for TEL in Isooctane

TEL Added, ML/Gal.	OCTANE NUMBERS	
	Research	Motor
0.0	100.0	100.0
0.2	101.9	104.5
0.5	104.5	108.0
1.0	106.2	110.5
2.0	106.5	114.0
3.0	106.5	116.5

Use of Extrapolated Octane Numbers

For an example of the use of the extrapolated Research octane numbers developed in this study, antiknock data were obtained on blends of isobutane-butylene alkylate and catalytically cracked naphtha containing 3.0 ml. TEL per gallon. Ratings in terms of isooctane plus TEL were obtained on the blends containing more than 70 percent alkylate, and these ratings were converted to extrapolated octane numbers. The data are presented in

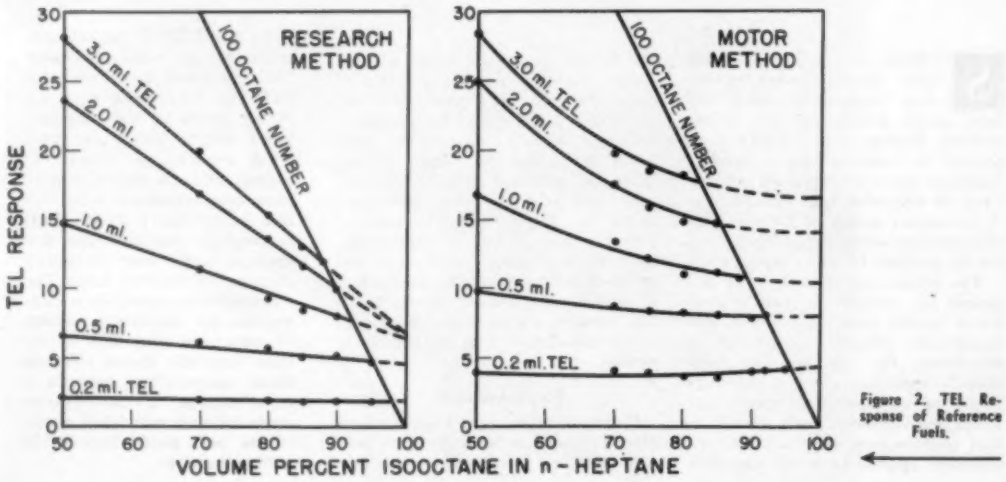

Figure 2. TEL Response of Reference Fuels.

Formula A

$$\text{Blending Octane Number of Alkylate} = \frac{100\left(\text{Octane Number of blend}\right) - \left(\text{Percent Naphtha in Blend} \times \text{Octane No. of Naphtha}\right)}{\text{Percent Alkylate in Blend}}$$

Table 3. The ratings, all on an octane-number basis, are plotted against blend composition in the lower curve of Figure 4. A smooth curve is shown, with no break at the point of crossing the 100-octane-number level, and with a maximum deviation from the curve of only 0.2 units.

Blending octane numbers were calculated for the alkylate component of each blend by Formula A, above. A constant value was used for the octane number of catalytically cracked naphtha, and extrapolated octane numbers were used for the ratings over 100. The blending octane numbers are shown in Table 3. These values are plotted as the upper curve in Figure 4 and show about the same deviation from a smooth curve as do the determined octane numbers.

Conclusion

The extrapolated octane number by the Research method is much lower than by the Motor method for a given rating in terms of isooctane plus TEL. With the sizeable difference that exists between the methods, one extrapolation obviously should not be used for the other. Extrapolated Research octane numbers above 100 fall on a single smooth curve with values below 100 when plotted against blend composition. Above isooctane + 1.5 ml. TEL, extrapolated octane numbers remain constant with increasing TEL values. In this range the method does not give significant antiknock ratings.

TABLE 3

Research Octane Ratings of Blends of Alkylate in Catalytically Cracked Naphtha (All Blends Contain 3.0 ml. TEL)

Volume Percent Alkylate	EVALUATION OF BLENDS		Alkylate Blending Octane Number
	Determined Ratings	Extrapolated Octane Number	
0.0	94.7	....	....
30.0	96.5	....	100.7
50.0	98.0	....	101.2
70.0	99.8	....	102.0
85.0	100 + 0.17	101.6	102.8
95.0	100 + 0.41	103.7	104.2
100.0	100 + 0.64	105.3	105.3

ACKNOWLEDGMENT

The author wishes to thank J. M. Snell for obtaining the antiknock ratings and to thank A. P. Lien and R. F. Marschner for their helpful suggestions.

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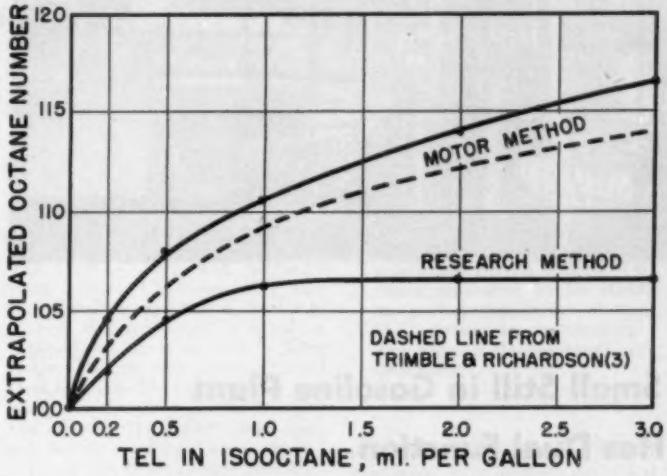

Figure 3. Extrapolated Octane Numbers for TEL in Isooctane.

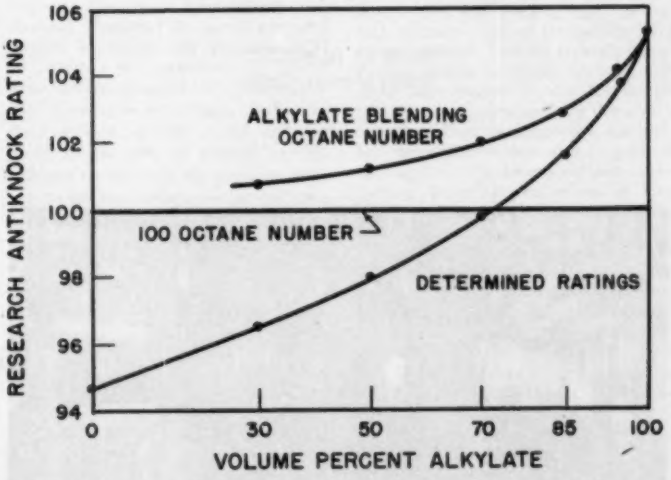

Figure 4. Research-Method Antiknock Ratings of Blends of Alkylate in Cracked Naphtha.

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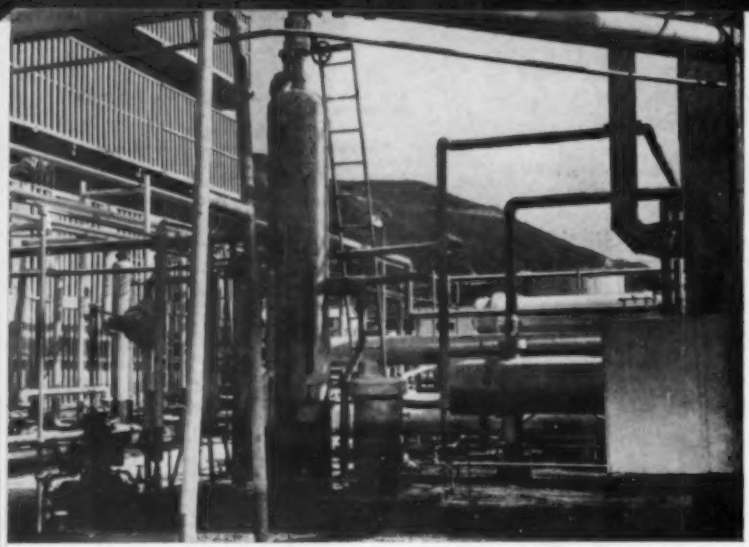

Figure 1. Distillation Unit Built for Purification of Absorption Oil which can be Switched to Rectify Pipe Line (Drip) Liquids. Steam-heated reboiler is small vertical vessel at right side of still.

Small Still in Gasoline Plant Has Dual Function

JOHN C. ALBRIGHT
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MANY gasoline plants encounter liquids in gas pipe lines, in many instances sufficiently contaminated with crude oil to prevent rectifying along with normal production, because of the hazard of fouling up the absorption oil and equipment. One method developed to handle these liquids (drips) is operating normally as the absorption oil rectifying unit, but connected so that it may be switched from absorption oil to handle batch quantities of the more or less contaminated liquids.

Only a small column is required for conventional absorption oil rectification, since the only cut obtained is separation of the absorption oil from the heavy sludge and fouling material which accumulates in the system. Likewise, when processing the pipe line liquids to rectify them into gasoline, the only cut is the gasoline recovered from the crude, which remains in the base of the still, or is piped into a disposal drum.

The unit, Figure 1, described here, contains all the essential equipment for distilling absorption oil, employing a steam heated reboiler at the side of the fractionation column, and an accumulator for the rectified product. Two sets of condensers are employed, one for the absorption oil, and the other in which the gasoline vapors are condensed to the accumulator at the side of the still. Gasoline is pumped continuously from the accumulator with a small duplex reciprocating steam pump. A liquid level controller (kidney valve type) on the accumulator is attached by means of an adjustable linkage system to the steam throttle on the small steam pump.

Since the liquid level controller is almost as large as the accumulator drum, and even larger than the small steam pump, the case of the controller is supported on a pedestal that is a continuation of the piping on the lower side of the instrument. The lower end of this pipe is closed with a blank where it enters the tee below the float case, Figure. 2. The pedestal is set on concrete to prevent settling and to insure the normal support for the large kidney valve.

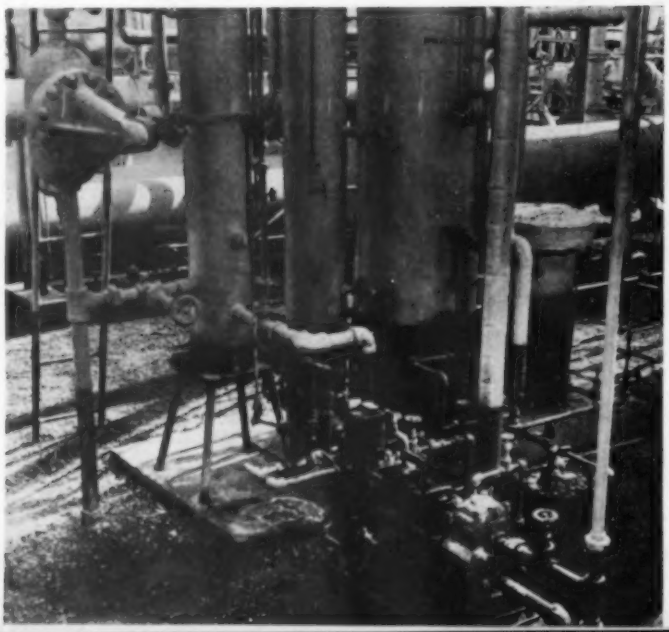

Figure 2.
Accumulator at Side of Still with Level Control which Operates Steam Throttling Valve on Small Duplex Steam Pump.

Pressure Drop Through Bubble Caps

PART I. INTRODUCTION

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BUBBLE TRAY performance is of vital importance in process plant operations, but the design of such equipment is still largely from empirical data and experience. This report of the development of tray pressure drop calculation methods along the lines of basic theory should have both interest and utility for designers. It will appear in three parts.

Dr. Huntington is chairman of the School of Chemical Engineering, University of Oklahoma and while Dr. Huitt was a faculty member there at one time, his present address is Magnolia Petroleum Company, Dallas. Their article is condensed from a portion of a thesis presented by Dr. Huitt as partial fulfillment of the Ph.D. degree in chemical engineering at the University of Oklahoma.

Abstract

THE pressure drop necessary to cause a vapor to flow through the submerged slots of a bubble cap has been determined by analysis of the static and dynamic forces opposing the flow of vapor.

Each factor causing a pressure drop has been treated separately, and its effect has been determined. The total pressure drop has been separated into individual pressure drops as follows: a) flow reversal, b) liquid seal, c) slot opening, d) surface tension, e) change of vapor velocity. Theoretical equations have been derived, and the constants in the equations evaluated by experimental results.

The relationships of the physical properties of the vapors and liquids and physical characteristics of the bubble cap to the individual pressure drops have been determined. A total of four gases including air, natural gas, propane, and carbon dioxide were studied. Six liquids were investigated including water, light and medium lube oils, glycerine, water-glycerine mixtures, and solutions of aerosol in water. Slots ranging in width from 0.11 to 0.375-inch and in length from 0.33 to 1.25-inches were analyzed. Bubble caps having from 1 to 32 slots were submerged in liquids to a liquid-seal depth of one to three inches. The gas flow rate was varied from incipient flow to above that necessary for the entire slot to be open. The effect of the liquid under static and flowing conditions was studied.

The effects of the surface tension of the liquid on the pressure drop and the minimum slot opening for incipient gas flow have been determined. Aerosol dissolved in water provided liquids having surface tensions of 37 to 72 dynes per centimeter. Graphical results were obtained for the minimum slot opening as a function of the surface tension of the liquid and the width of the slot. A method was developed to calculate the pressure drop due to the surface tension for gas rates from incipient flow to the point where the entire slot is open. Also, a method was developed to determine the length of the slot opening at various flow rates of gases through the submerged slots.

Introduction

In the many individual operations which employ fractionation, the bubble tray is one of the most important single pieces of process equipment. It has been estimated that distillation equipment makes up over one-half the investment for refinery process facilities.[8] The bubble tray represents only a fraction of this investment, but it still constitutes a sizeable amount. Many papers have been written on the factors involved in the design of bubble trays [3, 6, 8, 9, 11, 14, 15, 18, 19, 27, 28, 30] attacking the problem under different considerations. Progress has been made in deriving equations which can be used in designing a tray, but designers still rely to a reat extent upon experience.

Prior to World War II, major emphasis was placed on the design of columns from the standpoint of vapor capacity. The Sounders and Brown[28] equation,

$$W = C[d_v(d_l - d_v)]^{1/2} \qquad (1)$$

where W = mass velocity, lbs. per sq. ft. per hr.

d_l = density of liquid, lbs. per cu. ft.

d_v = density of vapor, lbs. per cu. ft.

C = a constant depending on plate spacing and surface tension.

is one of the best criteria offered for calculating column diameters on the basis of vapor velocity. Quite often little attention was given to the number of caps, and the tray was laid out with as many caps as the spacing and area permitted. To meet increased production demands during the war, columns were loaded beyond the design maximum as calculated by the above equation. Poor fractionation resulted, and investigation showed that some of the caps on the tray were not functioning properly. In some of the larger columns the efficiency was increased by closing off part of the caps. This corrective measure showed the necessity of knowing more about the mechanics of a bubble cap. Knowledge of the pressure required to make a cap pass vapor under various conditions as well as the pressure drop through a cap functioning properly are of primary importance in designing a tray.

The importance of the pressure drop through the bubble caps is often not agreed upon by different designers. Perry[20] states that for both atmospheric and pressure operation, pressure drops over plates are not a serious design limitation, providing that tolerances for liquid depth and percent of vapor riser and slot area are allowed. Rhys and Minich[24] noticed in their tests that when the vapor distribution on a tray was poor, the measured pressure drops were much higher than predicted. Several investigations, [5, 6, 7, 8, 12, 15, 17, 21, 22, 23, 24, 25, 29

offer means of predicting the pressure drop through either part or the whole bubble cap. Empirical equations are set forth with limitations to their use. No mention is made of the minimum pressure drop required to make the cap pass vapor.

Griswold[12] and Rogers and Thiele[23] offer equations for calculating the pressure drop based on the hypothesis that the pressure drop is determined by the difference between the liquid level inside and outside the cap. Sherwood[26] states that, at best, these equations are only approximations. The equations are valid up to the point at which the full height of the slots are operating, but no minimum pressure drop was indicated. Kirschbaum[16] offers an excellent qualitative discussion of the pressure drop but offers no means of calculation. He mentions that, after the static forces and frictional forces have been overcome, there still are the resistances offered by the cohesion of the bubbles in foam and the surface tension to be overcome. Cicalese, et al[6] offer the most complete method of calculating the pressure drop but do not consider the minimum pressure drop. Robinson and Gilliland[22] present an equation which includes the pressure drop due to surface tension, but the surface tension effect is considered constant for a given liquid. There are also equations[23, 29] which are offered to calculate the pressure drop of a slot fully operating by considering it as an orifice Harrington et al[13] state the pressure drop through bubble caps has become more important since the diameters of the fractionating columns have been increased, and there is a need for more research to be done.

In general, it appears that previous investigators have included the pressure drop factor in studies of other problems of tray design. Empirical equations are offered which correlate the data of a particular investigation but are of little value when applied to other cases. Thus, it seemed desirable to attack the pressure drop problem having in mind only the fundamental variables encountered when dealing with the flow of vapor and liquid through and around a bubble cap.

Theoretical Discussion

The pressure drop necessary to cause a vapor to flow through the submerged slots of a bubble cap is made up of both static and dynamic components. After the vapor leaves a tray in a fractionator, it rises to the tray above where it passes through the vapor riser and into the bubble cap. There is a pressure drop due to the contraction of the vapor upon entering the riser, flow through the riser, expansion of the vapor leaving the riser and entering the bubble cap, and the reversal of the direction of flow in the bubble cap. These losses will be referred to hereafter as the pressure drop due to flow reversal.

Before the vapor can reach the submerged slot, the static head of liquid above the top of the slot must be overcome. This is usually referred to as the liquid seal, and this pressure drop is that required to overcome the liquid seal. After this liquid seal effect has been overcome, the slots must have a "free" passage way for the vapor to pass through. This is another static liquid head, and is referred to as the pressure drop for the slot opening. A slot can be considered to have a "free" passage way if the liquid level inside the bubble cap is below the top of the slot. Once the liquid level inside the cap is below the top of the slot, the vapor will be in contact with the liquid outside the cap in the "open portion" of the slot. For this vapor to break away from the slot, there is an additional pressure necessary to overcome the surface tension acting against the bubbles leaving the outside of the slot. Finally, to get an adequate amount of vapor through the slots a velocity has to be given to the vapor, which again necessitates a pressure drop.

Pressure Drop Due to Flow Reversal

The first pressure drop to be considered is that due to flow reversal. It is a function of the vapor velocity, vapor density, and the dimensions of the cap. Obviously, this pressure drop will vary with each type of cap depending upon the height and diameter of the riser, the height and diameter of the cap, and the device used to hold the cap on the tray. Due to the numerous types of caps and methods of securing the cap on the tray, no attempt was made to derive an equation for calculating this pressure drop. When employing bubble caps in which the area of the riser, the clearance area at the top of the riser, and the area of the annular space between the cap and riser are equal, Robinson and Gilliland[21] suggest an equation by Dauphine[7] and Schneider[25] obtained from data on air. If a gas density term is placed in the equation and the constant changed, there results

$$\Delta P_r = 0.147 \frac{\rho_v Q_c^2}{D^4} \qquad (2)$$

where ΔP_r = pressure drop due to the flow reversal in lbs. per sq. ft.

ρ_v = density of vapor in lbs. per cu. ft.

Q_c = flow rate of vapor in cu. ft. per sec. per cap

D = diameter of riser in feet.

Pressure Drop Due to Liquid Seal

The liquid seal which is necessary for fractionation or other mass transfer operation is the next force to be overcome by the vapor. This static height of liquid has to be overcome by the vapor which pushes the liquid out of the cap until the liquid level in the cap is at the top of the slots. Since this is a static force, it may be calculated from the density of the liquid on the tray and the depth of the liquid seal by means of the equation,

$$\Delta P_s = \rho_l S \qquad (3)$$

where ΔP_s = pressure drop due to the liquid seal in lbs. per sq. ft.

ρ_l = density of liquid on tray in lbs. per cu. ft.

S = depth of seal in feet.

Pressure Drop Due to Slot Opening

At this point, the vapor is in the cap and the liquid level in the cap is at the top of the slots. An additional pressure is necessary to push the level of the liquid inside the cap below the top of the slots before the slots have an "opening." This pressure, which causes the level on the inside of the cap to fall below the top of the slot, is dependent upon the density of the liquid and the extent to which the slot is open. The extent to which the slot must open before vapor escapes the cap is a function of the surface tension of the liquid and width of the slot. The surface tension effect will be discussed later. The following paragraph deals solely with the pressure necessary to cause the liquid level in the cap to fall a distance, L, below the top of the slot.

Consider a slot W feet in width and L feet in height submerged in a liquid having a density of ρ_l pounds per cubic foot as shown by Diagram A.

Since the static pressure along the L axis varies, a determination of the center of pressure is necessary. This center of pressure is defined as the static pressure at the particular point applied along the L axis which is equal to the summation of the varying static pressures along the L axis from the top of the slot to the liquid level inside the cap. This can be determined from equation 4.

$$\bar{L} = \frac{\int_0^L L^2 \, dL}{\int_0^L L \, dL} \qquad (4)$$

Integration results in the center of pressure, L, equal to $\frac{2}{3}$ L. Therefore, the pressure necessary to lower the liquid level inside the cap from the top of the slot to some distance L below the

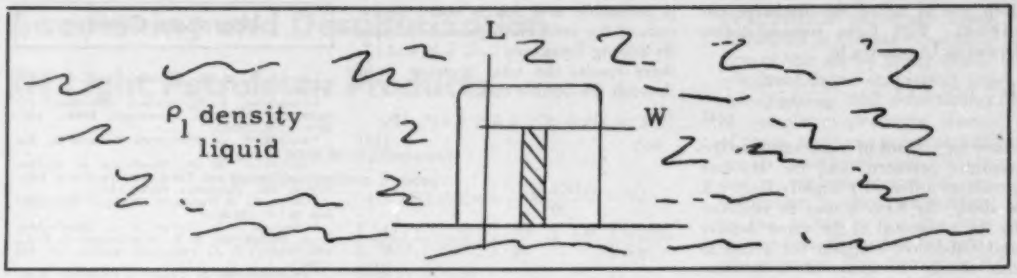

Diagram A

top of the slot can be calculated by

$$\Delta P_s = \frac{2\rho_l L}{3} \quad (5)$$

where ΔP_s = pressure drop in lbs. per sq. ft. caused by slot being opened L feet

ρ_l = density of liquid on tray in lbs. per cu. ft.

L = length of slot open in feet.

Pressure Drop Due to Surface Tension

The next pressure to be considered is that pressure necessary to cause the vapor to break through the open portion of the slot which has liquid outside the cap against the slot opening. The force opposing the breaking-away process of the vapor bubbles is the surface tension of the liquid. If the slot be considered analagous to a capillary tube,[2] the static pressure due to the surface tension against the bubble of vapor is

$$h\rho_l = \frac{2\delta}{gr} \quad (6)$$

where h = height of liquid rise in feet caused by the surface tension

ρ_l = density of the liquid in lbs. per cu. ft.

δ = surface tension in lbs. of force per ft.

g = gravitational constant

r = radius of the bubble in feet formed at the slot.

This expression is possible by assuming the contact angle is zero. The radius of curvature is dependent upon the length and width of the open slot, and the surface tension. From this analysis and the above equation, it can be seen that the pressure ($h\rho_l$) becomes less as the active length becomes greater. Bikerman[2] states that Bechhold[1] concluded there was a relationship between the surface tension, bubble radius, and pressure necessary to force the bubble through a membrane or small capillary. For the maximum pressure, the bubble radius is the radius of the opening through which the gas was forced. If r in Equation 6 be taken as the equivalent radius, an expression becomes possible to determine the maximum pressure for overcoming the surface tension effect.

The equivalent radius may be calculated by

$$r = \frac{\text{equivalent diameter}}{2} \frac{LW}{L+W} \quad (7)$$

where r = equivalent radius in feet

L = slot length in feet open to flow of vapor

W = slot width in feet.

Observations during this investigation showed that the bubbles coming from a submerged slot approached the dimensions of the open portion of the slot at incipient flow, and that the radius of curvature of the bubble of vapor was less at the top of the slot. This curvature is dependent upon δ, L, and W. A constant, k, inserted in Equation 6 and determined experimentally. Substituting Equation 7 for r in Equation 6 gives

$$\Delta P_\delta = \frac{2k\delta(L+W)}{gLW} \quad (8)$$

where ΔP_δ = maximum pressure drop in lbs. per sq. ft. due to the surface tension effect

L = length of slot in feet open to flow

W = width of slot in feet

g = gravitational constant

k = a constant

δ = surface tension of liquid, lbs. of force per ft.

Pressure Drop Due to the Change of Vapor Velocity

Finally, to obtain an adequate amount of vapor through the slots, a velocity has to be given to the vapor which again necessitates a pressure drop due to the orifice effect of the slots. To arrive at this pressure drop, an energy balance may be written.

Consider as the system the vapor going through the slot and as the surroundings those things opposing this flow other than the liquid on the tray and the surface tension. Let point 1 be in the annulus between the riser and cap and point 2 be in the slot. By an energy balance on a pound basis,

$$E_1 + P_1V_1 + X_1 + \frac{U_1^2}{2g} + q - w = E_2 + P_2V_2 + X_2 + \frac{U_2^2}{2g} \quad (9)$$

where E = internal energy

P = absolute pressure

V = volume

X = distance above some arbitrary datum plane

U = velocity of vapor

g = gravitational constant

q = heat transferred from surroundings

w = work done on surroundings by system.

Collecting like terms and replacing the difference of like terms by Δ quantities result in

$$\Delta E + \Delta(PV) + \Delta X + \frac{U_2^2 - U_1^2}{2g} = q - w \quad (10)$$

Considering only heat and compression energies, we have

$$\Delta E = \int T\,ds - \int P\,dV \quad (11)$$

and

$$q = \int T\,ds - w_f \quad (12)$$

where T = absolute temperature

s = entropy

w_f = work to overcome friction.

By rewriting $\Delta(PV)$ in Equation 10 as $PdV + VdP$ and substituting Equation 11 and Equation 12 into Equation 10, there results

$$\int_{P_1}^{P_2} VdP + \Delta X + \frac{U_2^2 - U_1^2}{2g} = -w_f - w \quad (13)$$

Since there is no work done, the term w is zero. The term w_f refers to the work to overcome the friction offered to the flow of the vapor through the slot which tends to serve as an orifice. This term is usually not retained as a separate quantity, but a constant, C, is placed in the equation to take care of the friction effect on the pressure

drop and is called the discharge coefficient. With these considerations, Equation 13 reduces to

$$\int_{P_1}^{P_2} V dP + \Delta X = -\frac{C(U_2^2 - U_1^2)}{2g} \quad (14)$$

Since the volume of a gas varies as the absolute pressure, and the absolute pressures differ only slightly since ΔX is small, the term V may be replaced by the reciprocal of the vapor density and considered constant for a cap as the change in temperature between points 1 and 2 is small. Thus, by neglecting the head of vapor of ΔX feet in height (at the most a few inches) and considering the vapor density constant for a single cap, Equation 14 may be integrated to give

$$P_1 - P_2 = \frac{C\rho_v(U_2^2 - U_1^2)}{2g} \quad (15)$$

By letting ΔP_o be the pressure drop between points 1 and 2, Equation 15 reduces to

$$\Delta P_o = \frac{C\rho_v(U_2^2 - U_1^2)}{2g} \quad (16)$$

By assuming the square of the average velocity equals the average of the velocities squared, there results

$$\Delta P_o = \frac{C\rho_v}{2g}\left[\frac{Q^2}{L^2W^2} - \frac{Q_c^2}{A^2}\right] \quad (17)$$

where ΔP_o = pressure drop in lbs. per sq. ft. due to the slot acting as an orifice

C = a constant

ρ_v = density of vapor in lbs. per cu. ft. passing through the slot

Q = volume of vapor in cu. ft. per sec. through the slot

Q_c = volume of vapor in cu. ft. per sec. through the cap

L = length of slot open in feet

W = width of slot open in feet

g = gravitational constant

A = cross sectional area of annulus between the riser and cap in sq. ft.

The vapor has entered the riser and passed through the slots. For this flow of vapor to take place, a pressure drop is necessary, and this is equal to the sum of the individual pressure drops. By adding Equations 2, 3, 5, 8, and 17, there results the total pressure drop through the bubble cap,

$$\Delta P = \Delta P_r + \Delta P_s + \Delta P_t + \Delta P_\delta \Delta P_o \quad (18)$$

or

$$\Delta P = \frac{0.147\rho_v Q_c^2}{D^4} + \rho_t S + 2/3\rho_t L + \frac{2k\delta(L+W)}{gLW} + \frac{C\rho_v}{2g}\left[\frac{Q^2}{L^2W^2} - \frac{Q_c^2}{A^2}\right] \quad (19)$$

It is worthwhile to note that no mention of viscosity was made in the derivation of the pressure drop equations. It is believed the viscosity of the liquid on the tray has no bearing on the pressure drop through the bubble cap. Actually, the vapor does not force its way through the liquid until it is free of the slots. After the vapor has once left the slots, it is no longer under the force of the vapor in the cap in the sense that it is restricted to direction of flow or size of channel in which to flow. There is possibly a pressure drop encountered as the liquid is being forced from the cap, but once the cap is operating this liquid only offers a static force due to its height.

The viscosity of the vapor is of minor importance because of the length of flow of the vapor through a restricted channel. Possibly the greatest effect would be in the riser, and since the riser in the cap is usually of the order of one to four inches high, this effect is probably negligible. The other possibility concerning the effect of viscosity on the pressure drop is in the flow of vapor through the slots. If the flow is incipient, the pressure drop due to the orifice effect is negligible. If the quantity is sufficient to result in a continuous flow of vapor through the slot, the Reynolds number would be such that the discharge coefficient would be nearly constant.

End of Part I. Part II will appear in an early issue.

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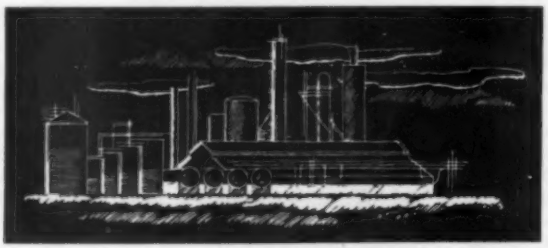

Sweetening and Desulfurization Of Light Petroleum Products

Part VIII—Miscellaneous Desulfurization Process

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IN ADDITION to the processes described in the previous articles of this series many methods have been suggested for desulfurizing and sweetening of petroleum products. Some of these methods were or still are in commercial use. Others are in various stages of development or offer possibilities in the future while the rest have been discarded for various reasons. The choice of a process for commercial use is often justified not on the basis of the improvement it may impart to a single oil property but on the over-all effect on the refined oil. With the progress of the industry new needs are created which may require radical changes in product specifications and introduction of new testing procedures. This might lead from time to time to the resurrection of the now obsolete refining methods and old ideas which are always open for revision.

EXTRACTION with selective solvents results in the concentration of sulfur compounds in the extract phase. However, aromatic compounds are removed in the extract which introduces considerable complications in applying this method to the refining of certain petroleum products. The method is quite satisfactory for improving the quality of kerosine which should be free of both aromatic and sulfur compounds. For this reason the Edeleanu process involving extraction with liquid sulfur dioxide found wide application in the kerosine manufacture. Characteristics of fuel oils and diesel fuels are improved by solvent refining and furfural is employed commercially for this purpose.[6] However, these oils are refined primarily for improving their burning quality and stability and sulfur removal is to a certain extent incidental.[11] In refining gasolines different problems are encountered. Aromatic compounds are the desirable gasoline constituents while the sulfur compounds are not. When the aromatic substances are extracted with solvents their sulfur content is much higher than that of the original stock and, unless the sulfur content is exceptionally low the aromatic extract must be further treated for sulfur removal. The raffinate phase is relatively free from sulfur but its anti-knock characteristics are impaired by the removal of aromatics.

The choice of solvent for extraction of light petroleum distillates is often difficult on account of boiling point limitations. Many selective solvents distill within the boiling range of light petroleum products which prevents their separation from the oil by distillation. It is possible to effect such separation by the use of secondary solvents like water but this adds considerably to the cost of refining and is not feasible commercially. The use of solvents having boiling points higher than the end point of the oil has been proposed but is open to several objections which prevented their acceptance by the industry. The temperature to which such solvents must be heated to distill off the last traces of oil is high and might cause decomposition of the solvents which are usually composed of relatively high molecular weight compounds. Leaving even small quantities of oil in the solvent leads to a gradual contamination of the solvent which necessitates its expensive reconditioning. Solvents suggested for extraction of light petroleum distillates are shown in Table 1, but only a few of them are used by the industry for the aforementioned reasons.

Sulfur dioxide is most widely employed for extraction of light petroleum products. Methods of applying it are discussed in detail by Kalichevsky and Stagner[12] and need not be repeated. Hydrogen fluoride has been suggested recently for similar purposes[20] and its selective solvent action with respect to various sulfur compounds has been studied.[13,16] Addition of boron fluoride to the anhydrous hydrogen fluoride is claimed to improve considerably its solvent characteristics.[9] However, hydrogen fluoride though used commercially is difficult to handle on account of its toxicity and corrosiveness.

The number of chemicals suggested as petroleum refining agents is considerable. These chemicals with the exception of those already described are listed in Table 2. Aluminum chloride is probably of most interest as it is a

TABLE 1
Selective Solvents Suggested for Refining Light Petroleum Oils

SOLVENT	U.S. Patent	Date	Inventor
Acetone and ammonia	2,047,755	7-14-36	Volck, W. H.
Aliphatic amino alcohols	2,287,118	6-23-42	Mottlau, A. Y.
Amyl acetate	587,291	3-31-06	Tempere, A. J.
Amyl alcohol followed by ethyl alcohol	305,181	9-16-84	Halvorson, H.
Cresylic acid	2,069,329	2- 2-37	Roelfsema, P. J.
Diethylene triamine	2,238,201	4-15-41	Wilson, A. L. and Fife, H.R.
Ethylene glycol	1,965,613	12-25-45	Polly, O. L. and Byrns, A. C.
Ethyl or methyl alcohol and sulfuric acid	951,272	3- 8-10	Frasch, H.
Ethylthioglycolic acid	2,393,645	9-25-45	Polly, O. L. and Byrns, A. C.
Furfural	1,550,523	8-18-25	Eichwald, E.
Fusel oil	38,015	3-24-63	Tyler, A. N.
Hydrogen fluoride	2,450,588	10- 5-48	Evering, B. J., Lien, A. P. and Page, J. M., Jr.
Hydrogen fluoride and boron fluoride	2,343,841	3- 7-44	Burk, R. E.
Mercaptols	2,422,341	6-17-47	Crouch, W. W.
Morpholine	2,261,866	11- 4-41	Agruss, M. S. and Ayers, G. W., Jr.
Nitro-or amino-biphenyl	2,131,990	10- 4-38	Clarke, L. A.
Phosphoric acid	2,334,378	11-16-43	Berger, C. W.
Polyhydric alcohol or its ether	2,013,663	9-10-35	Malisoff, W. M.
Sulfo acids and alkyl phenols	2,174,174	9-26-39	Greenfelder, B. A. and Speight, M. E.
Sulfur dioxide	911,553	2- 2-09	Edeleanu, L.
Sulfur dioxide and carbon dioxide	1,803,138	1- 3-33	Gary, W. W.
Sulfur dioxide and propane	2,034,495	3-17-36	Sullivan, F. W., Jr
	2,073,517	3- 9-37	Fitz Simons, O. and Bahlke, W. H.
	2,081,310	5-25-37	Sulzkow, P.
Sulfur dioxide and pyridine	2,063,597	12- 8-36	Fitz Simons, O. and Jack, R. A.
Sulfur dioxide followed by hydrogen fluoride	2,440,258	4-27-48	Elliott, L. P. and Holm, M. M.
Sulfur dioxide followed by sulfuric acid	1,868,333	7-19-32	Morrell, J. C. and Egloff, G.
Water	101,264	3-29-70	Loew, O.
Water at 400-600° F.	2,402,799	6-25-46	Arnold, G. B. and Atwell, H. H.

TABLE 2

Some of the Chemicals Suggested for Refining Light Petroleum Oils

TREATING AGENT	U. S. Patent	Date	Inventor
Aluminum chloride	1,277,326	8-27-18	McAfee, A. M.
	1,326,072	12-23-19	McAfee, A. M.
	1,570,006	1-19-26	Reinbold, H. and Reinbold, H.
	1,948,538	2-27-34	Malisoff, W. M.
Aluminum chloride and ammonium, barium, copper, lithium, magnesium, potassium, sodium or tin chloride	1,971,167	8-21-34	Sumpter, M. C.
Aluminum chloride and ethyl ether	1,709,791	7- 1-30	Leamon, W. G.
Aluminum chloride and nitromethane	2,019,772	11- 5-35	Van Peski, A. J.
Aluminum or zinc chloride and phenol	2,001,634	5-14-35	Stevens, D. R. and Gruse, W. A.
Aluminum chlorosulfate	1,649,394	11-15-27	Blumenberg, H., Jr.
Aluminum, copper, iron or lead derivative of wax phenate	2,320,047	5-25-43	Nygaard, E. M. and Reiff, O. M.
Aluminum or zinc chloride	1,950,736	3-13-34	Levine, I.
Aluminum or zinc chloride in ether or isopropyl alcohol solution	1,709,795	7- 1-30	Leamon, W. G.
Bog iron ore	1,312,375	8- 5-19	Whitman, J. C.
Borax, alum and sodium chloride followed by addition of sulfuric acid	901,411	10-20-08	Wynne, E. W.
Boron fluoride	2,416,465	2-25-47	Ass, W. N.
Cadmium	1,938,116	12- 5-33	Smith, W. A.
Cadmium-ammonium chloride or nitrate	1,890,314	2-28-33	Culmer, T. W.
Cadmium hydroxide	1,696,377	12-25-28	Black, J. C. and Low, W. H.
Cadmium hydroxide followed by air	2,365,983	12-26-44	Apgar, F. A.
Cadmium hydroxide in sodium hydroxide solution	1,696,377	12-25-28	Black, J. C. and Low, W. H.
Calcium carbide	793,026	6-20-05	Blackmore, H. S.
Calcium cyanamide	2,235,936	3-25-41	Lerch, W. B., Mathis, C. H. and Gatchell, E. J.
Calcium hydroxyhydrosulfide	1,787,570	1- 6-31	Dubbs, C. P.
Carbonyl of a metal	909,067	1- 2-09	Blackmore, H. S.
Copper	1,782,906	11-25-30	Cross, R.
Copper chloride or sulfate on fullers earth or silica gel	2,380,934	7-14-42	Morrell, J. C. and Benedict, W. L.
Copper hydrate	764,089	7- 5-04	Amend, O. P.
Copper nitrate or silicate and zinc silicate	1,938,117	12- 5-33	Smith, W. A.
Cuprous naphthenate	2,430,981	11-18-47	Hoover, C. O.
Ferric chlorid, alcohol, alum, arsenic acid, barium chloride benzene and naphthalene	2,232,971	2-18-41	Records, E. H. and Louttit, J. E.
Ferric chloride followed by molten sodium or sodamide	1,973,499	9-11-34	Morrell, J. C.
Ferric halide	1,545,440	7- 7-25	Neumann, H.
Ferric nitrate followed by sulfuric acid and sodium hydroxide	2,045,362	6-23-36	Comay, S.
Ferric oxide and fullers earth with or without sodium hydroxide	2,433,426	12-30-47	Capell, R. G. and Amera, R. C.
Ferric sulfate and sodium chloride deposited on an adsorbent	2,308,935	12- 1-42	Gholson, R. L.
Ferric sulfate and sulfuric acid on fullers earth	1,999,335	4-30-35	McDermott, F. J.
Formate of an aliphatic alcohol	1,732,371	10-22-29	Luther, M. and Pierob, K.
Hydrogen carbide	770,214	9-13-04	Blackmore, H. S.
Hydrogen chloride and a calcined mixture of silica hydrogel and aluminum, copper, or zinc hydrogel	2,073,012	2-17-42	Benedict, W. L. and Ahlberg, J. E.
Hydrogen chloride and aluminum, antimony, arsenic, bismuth, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, tin or zinc	1,920,347	8- 1-33	Day, R. B.
Hydrogen chloride and brass or other metal	1,937,573	12- 5-33	Day, R. B.
Hydrogen chloride and ferric sulfate	2,012,400	9- 3-35	Benedict, W. L. and Wirth III, C.
Hydrogen chloride and glucose	2,160,116	5-30-39	Bede, H. E.
Hydrogen chloride and tin or zinc oxide	2,057,639	10-13-36	Morrell, J. C. and Egloff, G.
Hydrogen chloride and zinc chloride	2,055,037	9-22-36	Day, R. B.
Hydrogen chloride and zinc or copper chloride	2,062,062	12- 8-36	Day, R. B.
Hydrogen chloride and zinc or mercury chloride	2,062,491	12- 8-36	Day, R. B.
Hydrogen chloride and zinc, tin or iron	1,920,270	8- 1-33	Morrell, J. C.
Hydrogen peroxide and acetic acid	1,972,102	9- 4-34	Malisoff, W. M.
Iron and copper salts and sodium chloride	744,730	11-24-03	Colin, T. F.
Iron, colloidal	1,944,170	1-23-34	Darlington, H. T
Iron-silica gel containing copper sulfide	1,882,146	10-11-32	Holmes, H. N.
Lead and carbon followed by sulfuric acid	550,747	4-21-96	Smith, C. A.
Manganese and acetylene compound	655,500	8- 7-00	Macalpine, T.
	686,663	11-12-01	Macalpine, T.
Manganese or lead colophonate or oleate	604,515	5-24-98	Bragg, J.
Mercuric chloride followed by alkali sulfide and redistillation with caustic	451,660	5- 5-91	Kendall, E. D.
Mercuric chloride in alcoholic solution	1,771,350	7-22-30	Ramage, A. S.
Mercury	1,692,756	11-20-28	Moran, R. C.
Mercury dissolved in a mixture of nitric and hydrochloric acids	63,749	4- 9-67	Restieaux, T.
Metal or metallic oxide having affinity for oxygen and sulfuric acid	693,907	11- 5-01	Colin, T. F.
Morpholine	2,045,057	6-23-36	Schulze, W. A.
Nitric oxide followed by ferrous sulfate	1,194,033	8- 8-16	Knottenbelt, H. W
Ozonised air followed by filtration	1,810,903	6-16-31	Ulrich, H.
Phenol or aminophenol solution containing hydrogen peroxide or sodium peroxide	2,015,038	9-17-35	Pevere, E. F.
Phosphoric acid and phenol, cresol or naphthol	2,081,563	11-24-36	Malisoff, W. M. and Hess, F. G.
Phosphorus pentoxide	1,914,953	6-20-33	Malishev, B.
	2,191,043	2-20-40	Sachs, A. P.
Potassium ferricyanide	1,888,382	11-22-32	Heath, F. W.
Potassium phosphate	2,336,651	12-14-43	Stratford, R. K.
Salts of heavy metals deposited on adsorbents and ignited	1,778,517	10-14-30	Benner, R. C. and Thompson, A. P.
Salts of metals on inorganic gels	1,515,733	11-18-24	Cross, R.
Silver manganite or permanganite and an acidic oxide of manganese	2,314,576	3-23-43	Doran, A. B.
Soap solution followed by acid and alkali	1,438,764	12-12-22	Johansen, E. M.
Sodium	1,964,687	6-26-32	Fields, J. D.
	2,078,468	4-27-37	Stratford, W. M.
Sodium addition compound of anthracene, biphenyl or naphthalene and ether	2,048,169	7-21-36	Scott, N. D.
Sodium ferrite	2,090,190	8-17-37	Dolbear, C. E.
Sodium hydroxide and lead oxide on fullers earth	1,903,094	3-28-33	Darrow, M. S. and Sweeney, L. S.
Sodium, potassium or lithium	1,964,719	6-26-32	Fields, J. D.
Sodium, potassium or lithium followed with aluminum, iron, magnesium or zinc chloride	1,983,220	12- 4-34	Fields, J. D.
Sulfinic acid	2,204,903	6-18-40	McKittrick, D. S.
Sulfur dioxide, oxygen and ferric sulfate	1,855,496	4-26-32	Morrell, J. C. and Egloff, G.
Sulfur in the presence of a catalyst	1,795,278	3- 3-31	Fischer, H. G. M.
Tin tetrahalide on a carrier	1,645,530	10-18-27	Helthaler, T.
Titanium tetrachloride	1,943,272	9-20-27	Helthaler, T.
Uranium nitrate and aluminum chloride	2,026,492	12-31-35	Bennett, H. T., Hopkins, H. H. and Marshall, J. R.
Zinc chloride and ether	1,709,792-3	7- 1-30	Leamon, W. G.
Zinc chloride on clay	1,584,035	9-11-28	Kauffman, H. L. and Clark, I. A.
Zinc chloride, plaster of Paris and ether	1,709,794	7- 1-30	Leamon, W. G.
Zinc silicate and hydrogen chloride reaction product	2,189,058	2- 6-40	Day, R. B.

good desulfurizing agent and is used in the various chemical and petroleum refining processes. The extent of desulfurization secured with the anhydrous reagent depends upon the quantity of the reagent employed, time and temperature of contact, and types of sulfur compounds present in the oil. Besides its desulfurizing action aluminum chloride is also a polymerizing and saturating agent. For this reason consumption of the reagent and treating losses are high if aluminum chloride is applied to unsaturated products.[12] Although the cost of aluminum chloride is surprisingly low for a chemical of this type it is still fairly high for its wide acceptance by the petroleum industry. Difficulties are also encountered in maintaining the activity of this reagent in transportation and storage.

When used as a desulfurizing agent anhydrous aluminum chloride is contacted with the oil at 70-120° F. for a predetermined length of time which may vary from less than one to several hours depending on the nature of charge stock.[5] No advantage is gained by prolonging the time of contact beyond this optimum. The sludge obtained from this treat may be used for pretreating a fresh portion of oil. The spent sludge is decomposed by contacting it with water which liberates hydrogen chloride. The oily layer containing a large percentage of sulfur compounds is separated and may be employed for manufacturing mercaptans and sulfides.[22] The refined oil is always washed with a caustic solution in order to remove hydrogen chloride which is produced in the course of treating.

Percolation through adsorbents re-

duces the sulfur content of petroleum oils but the quantity of adsorbents required to effect a reasonable degree of desulfurization is high thus making the process of little commercial interest from the point of view of desulfurization.[13] Removal of sulfur compounds from the oil is affected by the adsorbent to oil ratio, the time and temperature of contact, the nature of the adsorbent and the type of sulfur compounds present. Adsorbents vary considerably with respect to their ability of removing sulfur compounds.[14] Alumina or bauxite[9] silica and similar gels,[4] reflocculated solid adsorbents,[1] mixtures of activated silica and alumina gels,[21] Wyoming rock clay,[22] activated carbon[17] and similar substances were recommended as desulfurizing agents. However, fuller's earth is in this respect considerably less efficient than the above mentioned materials. Because of the generally poor desulfurizing efficiencies adsorbents are very seldom used as desulfurizing agents and are employed primarily for decolorizing the oils or for improving such properties as demulsibility.

Bauxite is one of the few adsorbents which was used for desulfurizing kerosine.[12] Silica gel offers excellent possibilities as an analytical agent for laboratory separation of the individual sulfur compounds,[7,13] and it is conceivable that it may find some commercial application in the future. Both bauxite[2] and silica gel[19] were recommended for desulfurization of triisobutylene. Experiences show that best results are secured in most instances by employing bauxite completely free of moisture which may require charging the adsorbent from the kiln directly to the percolation filters and maintaining relatively high percolation temperatures.[12] It is of interest that the total sulfur content of gasoline obtained after filtering through silica gel may first show a decrease and then an increase as the percolation proceeds.[14] This indicates desorption of sulfur compounds caused by some of the gasoline constituents present in small quantities in the charge stocks. Claims were advanced that pretreatment of the oil with actinic rays[16] or X-rays[15] before applying the adsorbents results in a doctor sweet product.

The contact method of applying adsorbents is much less effective than percolation for sulfur removal. However, in either case the desulfurizing action is small and is usually neglected in plant practice.

The base-exchange chemicals of the zeolite type[10] were recommended as desulfurizing agents but are not yet widely used. Contacting the oil with mercuric or cadmium oxide to convert mercaptans to mercaptides is claimed to improve the sulfur removing properties of the zeolites.[3]

The choice of the most economical method for desulfurizing oils is not an easy problem and the best solution of it varies with the individual refineries. Because of the inherent differences in the processing methods and nature of the crude oil charge direct comparison between the various desulfurizing and sweetening processes which would be valid under all conditions cannot be made. Only in a few specific instances such comparisons are of value namely, when the refining schemes and charge stocks are similar. For this reason oversimplification of the treating problems is to be avoided and careful attention should be paid to the local conditions if maximum returns are expected on the investment. It also explains the necessity of maintaining technical and research organizations at the refineries where these and a large variety of other questions can be answered without the necessity of increasing the number of assumptions on which the decisions are based.

End of part VIII and series.

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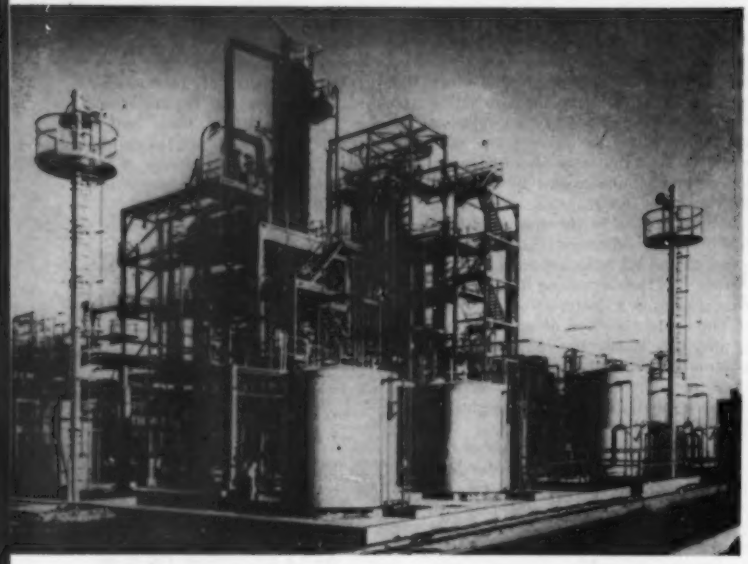
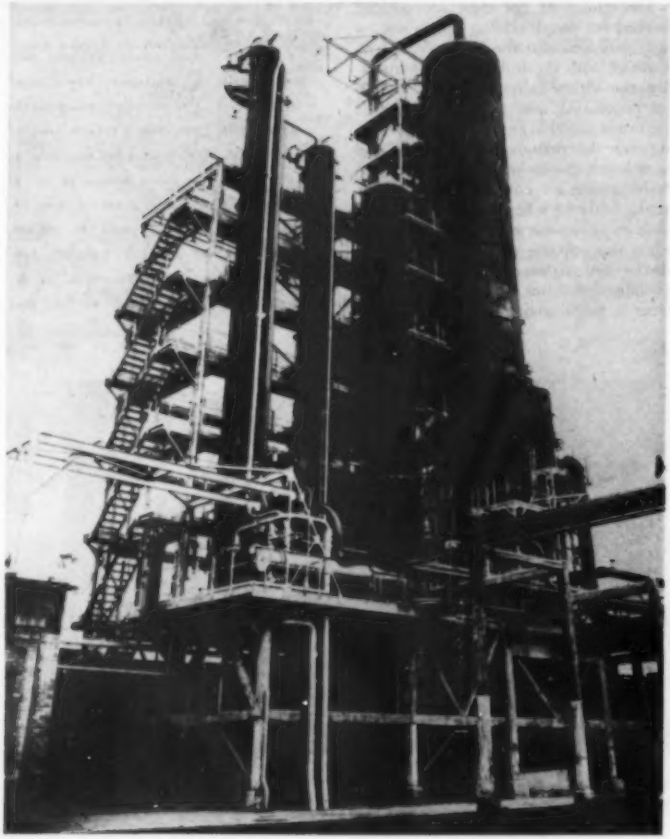
FIRST CARGO ALBERTA CRUDE—Largest lake tanker in the world, the Imperial Leduc, is shown at the dock in Sarnia, Ont., soon after she reached port on Tuesday, April 24, with the first cargo of Alberta crude oil to be delivered in Ontario. Towers of Imperial Oil Company's refinery are shown at left. The Leduc picked up the oil at the Interprovincial pipe line terminus at Superior, Wis.





Refining Developments In Scotland

DR. E. N. TIRATSOO
London

THE $17 million extension to the Scottish Oils Ltd. refinery project at Grangemouth—the first part to be completed in this $55 million project—went into operation late in March. An official opening will be held later in the year.

The new development, started two years ago, involved the construction of a major power station, large cooling towers and a modern refinery unit as well as the construction of a pipe line across Scotland, work on which is nearing completion. When completed, the entire project will also include a catalytic cracking unit of the most modern design, a catalytic polymerization plant to produce high octane gasoline from the light gases already produced, as well as auxiliary processing units.

The Grangemouth refinery is owned by Scottish Oils Ltd., of the Anglo-Iranian group. It is an established plant dating back to 1924, which has been greatly enlarged and will, when complete, be one of the most up-to-date oil refineries in Britain.

This is part of a scheme of expansion being undertaken by Anglo-Iranian in Scotland. Besides the reconstruction of Grangemouth refinery itself, the group has built a crude oil pipe line across Scotland from west to east and, in conjunction with The Distillers Company and Monsanto Chemicals, is constructing an important plant for the production of chemicals from petroleum on adjacent sites.

The capacity of Grangemouth refinery will be raised this spring to 12.6 million barrels a year; before the war its capacity was 2.5 million barrels a year.

New administrative buildings, laboratories, boiler house and electric generating plant are also being added. The com-

Top Photo: Phosphoric Acid Plant at Grangemouth.

Lower Photo: Scottish Oil's Crude Oil Topping Unit.

Top Photo: Another view of Phosphoric Acid Plant.

Lower Photo: Main Pipe Track at Grangemouth.

pany already has a housing estate of 100 houses to accommodate key employes. This is being extended by another 160 houses.

The important aspect of this new area and the plants involved is that they offer Scotland a new scope in the chemical field as well as providing a valuable source of high octane gasoline. Plans are being prepared by the companies involved for the major expansion of chemical and allied production from the plant.

Hitherto, crude oil has been imported via the Firth of Forth, on which Grangemouth stands. The new Scottish pipe line, however, which was recently completed, will give access to deeper water in Loch Long, where a new unloading terminal is being built at Finnart, enabling Grangemouth to be supplied by the largest sized tankers.

Adjoining Grangemouth, and nearing completion, is the plant of British Petroleum Chemicals Ltd., a joint undertaking of Anglo-Iranian and Distillers Company. Among other products it will produce industrial alcohol.

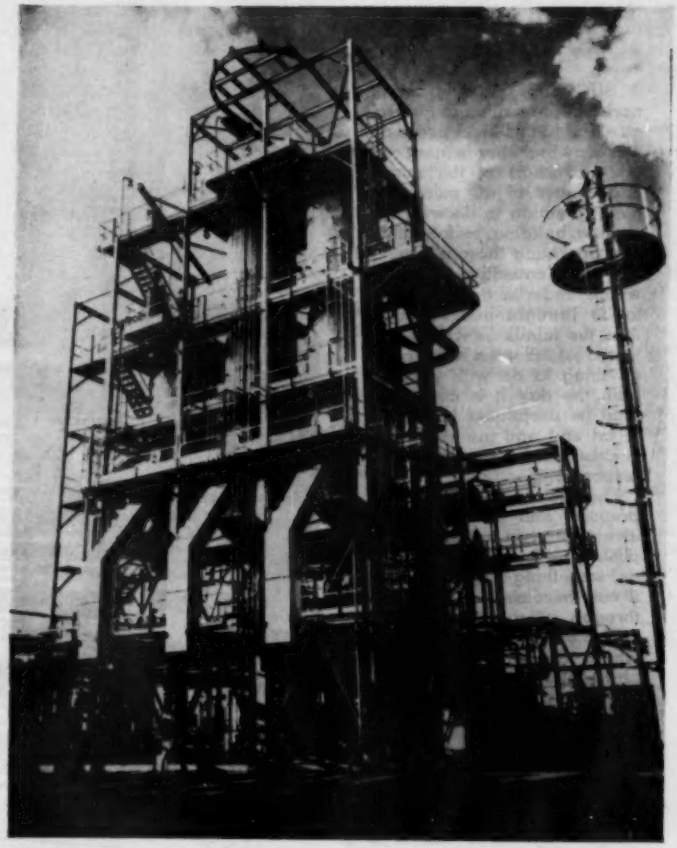
Another factory close by will be built by Forth Chemicals Ltd., a company owned jointly by British Petroleum Chemicals and Monsanto Chemicals. It will produce monomeric styrene, a material used in the plastics industry.

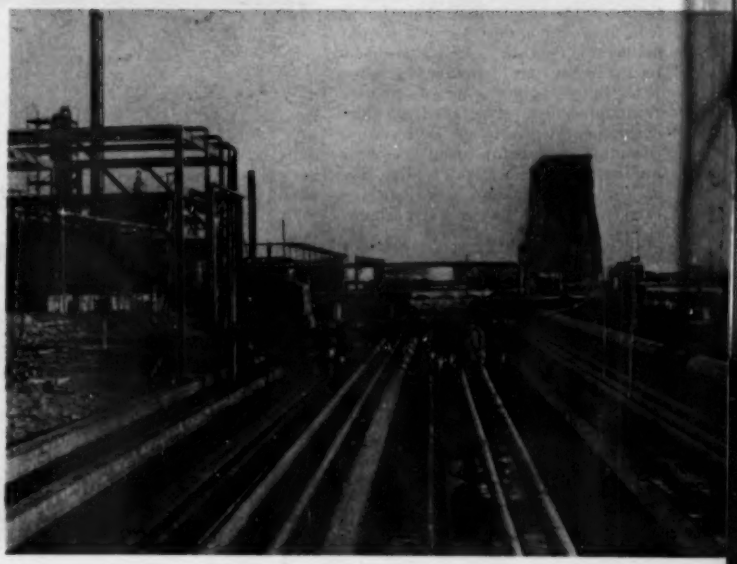
Heavy engineering equipment will be moved in during the coming months, the largest being a steel column 80 feet long and 16 feet in diameter, and weighing 120 tons, from a boiler works at Motherwell, 30 miles distant, to the refinery at Grangemouth. It will be moved by highway.

Experience in moving such large loads has already been gained, since last year a column measuring 96 feet by 13 feet and weighing 67 tons was taken from Motherwell to Grangemouth. The new column will form part of the catalytic cracking plant at Grangemouth.

The same manufacturers are also supplying a column measuring 76 feet by 16 feet to Anglo-Iranian's refinery at Llandarcy, South Wales. It will be moved by road to Glasgow and then towed down to Swansea by water via the Clyde and west coast.

A London company is making a number of large columns and towers at its Woolwich works. Two of these, each 106 feet long, 12 feet in diameter and weighing 65 tons, will be delivered by road, one to Llandarcy and one to Anglo-Iranian's new Kent refinery which is being built on the Isle of Grain at the junction of the Thames and the Medway. The Kent refinery will also be receiving, by road from the same makers, a 120-ton tower early in 1952.

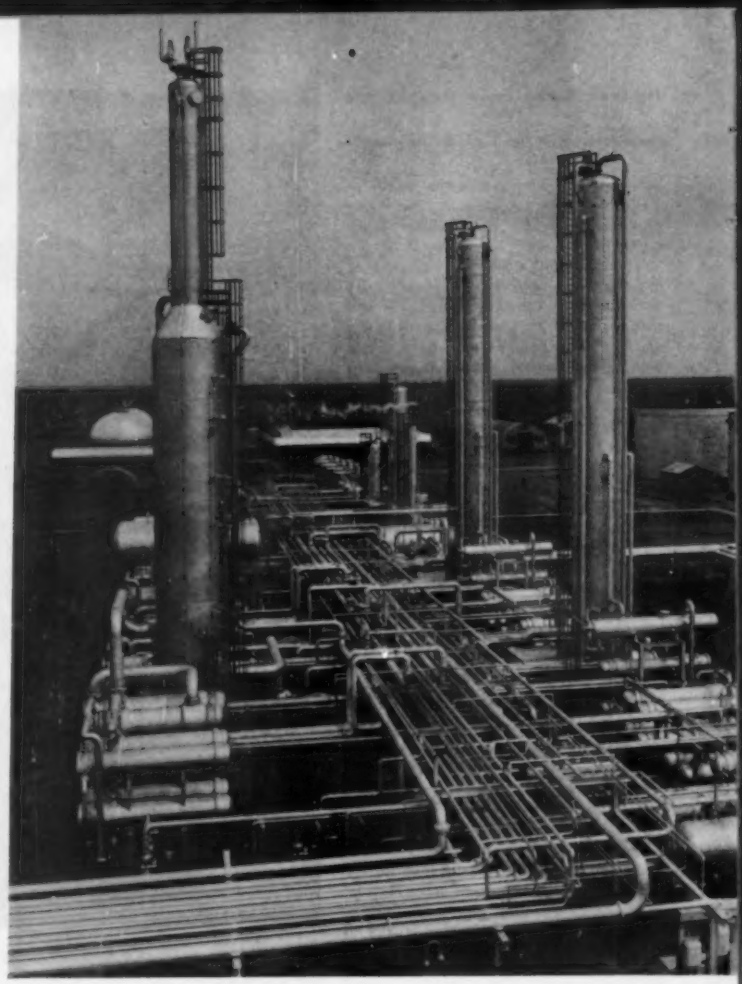




A SUCCESSFUL program of accident prevention in natural gasoline plants must begin on the drawing boards and can not end short of the minds and hearts of all men who have anything to do with designing, building, maintaining, and operating those plants.

If the causative factors which underlie accidents are to be brought under control then the minds as well as the hands of all men who have anything to do with a plant, from the day it is conceived until its usefulness has come to an end and the last valve is closed, must accept definite responsibilities.

The safety of men and property and the security of investment can not be accomplished as a side-line venture, as something superimposed; it can become a reality only through a program designed to make safety a definite, specific, and integral part of each phase of every job.



Safety Depends Upon Men Who Carry Its Banner

H. W. BOGGESS
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IT IS axiomatic that accidents do not "just happen." It is well established that they are caused. It is definitely known that accident causes can be determined and isolated and that more than ninety per cent of them can be controlled. This being true, it would appear to be a simple matter to turn in a good accident record in any gasoline plant year after year. But it is not a simple matter. Accomplishment of a good accident experience depends up engineering, education, and enforcement, the well publicized formula of safety. But, like all formulas, it is important that these three ingredients be properly proportioned.

It is about the proportion of the safety formula's ingredients—one in particular—to which I will largely confine these remarks.

It is well to realize that it is not enough for management to resolve to choose a good plant site, to blue print a well engineered layout of facilities, to install only the best equipment and then see to it that workmen have good tools, proper environment, a healthful atmosphere and ample safeguards. These things are proper and certainly play an important part in operating efficiency, but they will not insure an accident-free operation for the simple reason that no place of work can be made foolproof.

Engineering and enforcement, indispensable ingredients in an accident prevention formula, are not enough and will not produce a curative medicine for accidents without a well balanced proportion of education.

Fine Plants, Poor Records

The record, many times established and well authenticated, shows that some of the most modern plants in

America, products of keen, able, and experienced engineering minds, plants that have been intelligently conceived and designed, adequately constructed and equipped with the best obtainable materials, machines and tools, fitted with the latest safeguards, have produced very poor accident records. On the other hand, there have been plants that smack of the vintage of the gay nineties, having grown up like Topsy, without the benefit of vision, foresight, and planning, plants equipped with untested pressure vessels, hazardous machines, obsolete tools and marginal equipment, which have produced some of this country's best accident records.

What is the reason for such a seeming paradox? Why will safe tools, machines, and equipment fail in curtailing industrial accidents while an operation with subpar physical standards occasionally produces a perfect record? The answer lies in the hearts and minds of the men who daily run the risks of injuries.

It is on this one phase, the human factor as it relates to accident prevention, that this article considers. In doing so, it should be understood that there is no intention to minimize the importance of other factors. The purpose is to clearly emphasize that without appropriate and sufficient attention to the human element, an accident prevention program can fail.

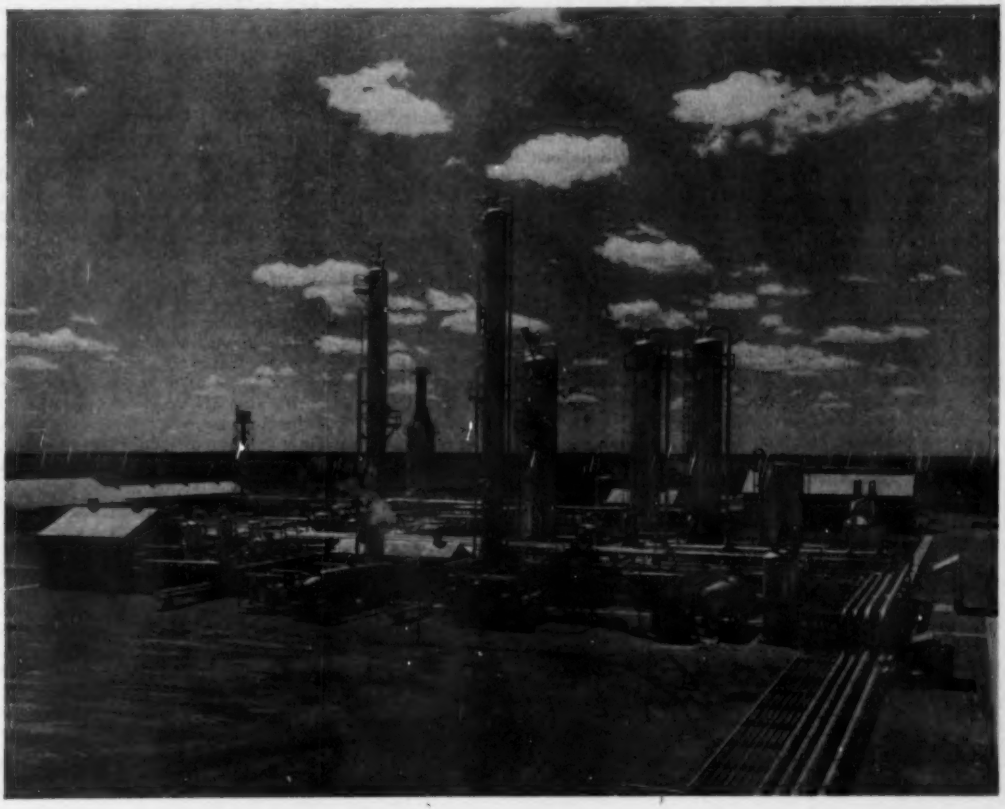
This is the age of specialization, the age of specific doctrines. Our vision can be clouded and our view obstructed; we are apt to look upon all problems as being so specific as to yield to specific answers. This is the age when one certain vaccine will prevent diphtheria, another specific one will prevent smallpox, while dozens of specific cures of as many different ailments can be made with as many individual medicines. In such an age, we are apt to lose perspective and to come to false conclusions.

We should first realize that accidents cannot be prevented by any specific vaccine; they cannot be cured by any single antidote. Accidents are not the product of a single germ, as is diphtheria or smallpox. An accident, any accidents, has many cause factors, primary and secondary, and can be counteracted only by multiple remedies. But no remedy for accidents will prove fully effective unless its formula contains ingredients designed to stimulate, capture, direct, and mold the human mind. That is education.

Need for Education

One of the foremost responsibilities of management, and management includes foremen and superintendents, is to inculcate a sense of safety consciousness in all men who run the risks of injury. The only path that leads to the door of this accomplishment is education. The mandate is clear and can not be escaped; if efficient productivity is to be maintained, void of accidents and their resultant high costs, demoralization and heartaches, then each member of management from foremen up, must be an effective teacher.

It is quite easy to be deceived and to think that industrial training may not be necessary. It is the course of least resistance to try and hire and work only experienced men who already possess the know-how of every job. It is easy to conclude that because no man wants to get hurt, or to cause injury or accident, he will automatically take necessary steps to prevent



such occurrences. Such thinking carries the so-called first law of nature, the law of self preservation, too far. Such a conclusion overlooks, or at least discounts, the heritage and the environment, hence the beliefs, the fixations, the complexes and the habits of the human animal.

Industrial training must be geared to meet these human frailties head-on; it must be designed to accept the challenge of man's inherent weaknesses.

Just what are some of man's inherent weaknesses that contribute to inefficiences, to high operating costs, to accidents and disasters? They are many, not the least of which are the *bravery* and *bargain* complexes.

Bravery Complex

The bravery complex goes back to the Garden of Eden where Eve defied the command of God and partook of the forbidden fruit. The men of Sparta preferred death to compromise; Hannibal knew how to incite his men to almost super-human deeds which made life cheap. History is replete with acts of bravery which nullified the so-called law of self preservation. Bravery is an inborn human trait in most normal men. No man wants his associates to think of him as "yellow." Bravery is a complex and it is a causative factor which underlies many industrial accidents, injuries, and catastrophes. In every accident where chance taking is know to have existed, the bravery complex is responsible.

Certainly there should be no quarrel with bravery as a human trait; it has done much to conquer the wild domains of the earth, to further man's progress and make life and happiness more secure, and to otherwise elevate the standards of civilization. So has fire been a noble servant; yet it also does much harm. Fire and the bravery complex are both useful and dangerous and each must be controlled. The question is: just how much of the bravery complex is serviceable to American industry; just how much is detrimental? The inherent bravery trait must be understood and controlled or it will contribute to inefficiencies and loss just as will fire.

The trouble with the bravery complex seems to be that only few men fully understand just what bravery really is. Do all men understand and appreciate that unnecessary chance-taking is not bravery? Evidently not; at least the acident record fails to indicate as much. Men must be taught, they must understand and believe that unnecessary chance-taking is just the reverse of bravery, that it is foolish and gambling in its most frenzied state.

Necessary chance-taking may be bravery, but never unnecessary chance-taking. It is brave for a man to enter a tank containing lethal gasses without adequate protection? No, it is foolish. It is necessary for a man to wheel his car out of line and pass a vehicle on a blind curve? No, it is foolish. Yet, there are altogether too many men who seem to think that taking such unnecessary chances stamps them as brave.

Not two out of ten thousands industrial accidents come from necessary chances taken by fearless hearts. Altogether too many come from unnecessary chances taken by unthinking men. Industrial management must accept the duty of convincing men that chance-taking, quite the reverse of being brave, is gambling in its most frenzied state. Management must realize that even though no man desires to sustain injury or to meet premature death, he is quite apt to do so unless he is taught and made to understand that *any man's willingness to die is proportioned to his willingness to take a chance!*

No Every-Time Winning

With life and limb at stake, unnecessary chance-taking is gambling against tremendous odds; the chance-taker must win every time to win at all. Who would play poker or shoot craps knowing that one single failure to win meant losing health or even life? Sane men do not do such things, yet smoking in a gas-filled area, welding on an unpurged vessel containing combustible mixtures, even being near a welding job without proper goggles, or any other kind of unnecessary chance-taking, means that health and life is being staked to win *every time!* Is it not evident that the natural tendency of men to flaunt fear must be controlled by management? You must be an educator to do it.

It always should be remembered that safety is not a destination. It is a journey; it is a road to travel, not an inn at which to rest. Safety education is a day-by-day job: it must be a continuing process to forestall bad patterns of habit which lead to routine chance-taking and eventual regret. The man who today may have high ideals, proper mental attitudes, and a resolve to satisfy his own sensitive conscience, may tomorrow suffer from disillusionment and adopt an "I don't care" philosophy. Because a man once understands and knows a thing is no sign he will always do so. Someone has wisely said that the greatest capacity of the human mind is the capacity to forget.

What a man thinks he knows today, he questions tomorrow. What he is for today, he may be against tomorrow. Invariably he will conclude that rules are not necessarily written for him, all the while admitting that they are good for the other fellow. Man's very nature makes him instinctively seek a bargain; he not only seeks a cheaper loaf of broad, he also seeks short cuts in work routines which are often extremely unsafe. Once he establishes a pattern of habit, he stubbornly defends his reason for doing so because he pridefully tells himself that he is smart enough to control his own circumstances and destinies. These and many other such tendencies are contrary to safety; they are contrary to the interests of efficient production. Safety and efficiency go hand in hand. A job cannot be efficiently done that is not safely done.

Man is the product of emotions, complexes, inhibitions, and misunderstandings. These are common human tendencies that come from inheritance and from environment.

Man falls easy prey to fear, envy, anger, worry, hate, and jealousy—even happiness will sway and control him. Emotional stability is rare in the human animal.

Intelligent supervision includes the detection of man's physical, mental, emotional, and moral weaknesses just as it includes the detection of inefficient tools, work processes, and substandard products. Intelligent supervision implies the ability to control the man who runs the still or handles the loading rack just as well as it implies the ability to control the product that comes from either.

All men need supervision, counsel, and advice—without these they fail to develop their full talents and fail to arrive at maximum productivity. Remember that every corporate president has a board of directors. And on the firing line of American industry, out where our nation's products are made, it is the duty of industry to supervise, to counsel, and to advise. Industry fails in leadership if it does not do so. That is what is meant by industrial education.

These are the reasons for concluding that the safety job cannot end until it reaches, and influences, the hearts and minds of men. These are the reasons for concluding that safety depends more upon the men who carry its banner than upon the dollars that pay its way.

ACKNOWLEDGMENT

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THERMOCHEMISTRY for the Petrochemical Industry

Part XVI—Five-Pointed Lagrangian Interpolation Coefficients for Transforming Thermochemical Values on the Kelvin to Other Thermometric Scales

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WHEN THE engineer needs values of enthalpy, heat capacity, entropy, or other thermodynamic data for an unusual compound, he usually finds the values of the function tabulated on the Kelvin temperature scale. The values desired may be on the Rankine, Centigrade, or Fahrenheit temperature scale so that interpolation is required to obtain values on one scale from those on another. This article deals with this problem of interpolation.

VARIOUS INTERPOLATION formulas are available, particularly when the values of the argument (temperature, in this case) are given at regular intervals. A more general equation which can also be used when the intervals are irregular is the Lagrangain interpolation formula.[4] This is a systematic way of writing a polynomial passing through any number of points. For this work the five-point formula has been selected because of the greater accuracy it gives. Three, four or more points could have been selected. This method is perfectly general, and it may be applied to any pair of variables. The general case will be written for enthalpy, H, at any temperature, T, in terms of known sets of values of the variables.

$$H = H_1\left[\frac{(T-T_2)(T-T_3)(T-T_4)(T-T_5)}{(T_1-T_2)(T_1-T_3)(T_1-T_4)(T_1-T_5)}\right] + H_2\left[\frac{(T-T_1)(T-T_3)(T-T_4)(T-T_5)}{(T_2-T_1)(T_2-T_3)(T_2-T_4)(T_2-T_5)}\right] + H_3\left[\frac{(T-T_1)(T-T_2)(T-T_4)(T-T_5)}{(T_3-T_1)(T_3-T_2)(T_3-T_4)(T_3-T_5)}\right] + H_4\left[\frac{(T-T_1)(T-T_2)(T-T_3)(T-T_5)}{(T_4-T_1)(T_4-T_2)(T_4-T_3)(T_4-T_5)}\right] + H_5\left[\frac{(T-T_1)(T-T_2)(T-T_3)(T-T_4)}{(T_5-T_1)(T_5-T_2)(T_5-T_3)(T_5-T_4)}\right] + R_5$$

The term R_5 is the remainder that has been disregarded as not affecting the result. Normally the values would be selected so that T_3 would be near the value of T for which H is being calculated; however, values near the end of the polynomial series can be calculated with accuracy.

The general form of the Lagrangian equation is immediately apparent. If it is reduced to a two-point formula by eliminating all known values except H_1 at T_1 and H_2 at T_2, the formula becomes a linear interpolation between two points. If the three-point or four-point equation is desired, the terms to be dropped are apparent. It is again stressed that the values of the argument (T_1, T_2, T_3, etc.) need not be at regular intervals, as is the case with the data available in this work. The engineer will find this equation of broad general utility.

In the work reported in this series, Parts I to XIV,[2] it has been necessary to convert thermochemical quantities from the Kelvin scale to the other three thermometric scales. Interpolation coefficients have been calculated using the five-point formula and these are given in Tables 2, 3 and 4.

To illustrate the use of the equation and tables in converting values from the Kelvin scale to other scales, the data for sulfur dioxide[3] will be used; and these are given in Table 1. To calculate the heat capacity at 1000° F. (810.94° K.), T_1 is selected as 600, T_2 700, T_3 800, T_4 900, and T_5 as 1000° K. The coefficients in Table 4 for 1000° F. are selected and each coefficient is multiplied by the value of $C°_p$ corresponding to its value of T. At 1000° F.:

TABLE 1
Heat Capacity and Enthalpy of Sulfur Dioxide

T°K.	$C°_p$ cal/g-mole °C.	H° cal/g-mole	t°F.	$C°_p$ Btu./lb-mole °F.	H° Btu./lb-mole
273	9.31	0.0	32	9.31	0.0
300	9.54	254.4	60	9.43	262.6
400	10.40	1251	77	9.52	423.9
500	11.11	2329	100	9.62	644.6
600	11.68	3468	300	10.12	1633
700	12.13	4661	500	10.57	2867
800	12.48	5891	700	10.97	3743
900	12.71	7150	800	11.31	4836
1000	12.91	8431	900	11.62	6004
1100	13.06	9729	700	11.90	7181
1200	13.18	11040	800	12.13	8388
1300	13.28	12360	900	12.33	9608
1400	13.36	13700	1000	12.49	10840
1500	13.43	15040	1100	12.63	12100
....	.....	.....	1200	12.76	13370
....	.....	.....	1300	12.86	14660
....	.....	.....	1400	12.96	15950
....	.....	.....	1500	13.04	17250
....	.....	.....	1600	13.11	18550
....	.....	.....	1700	13.18	19860
....	.....	.....	1800	13.24	21180
....	.....	.....	1900	13.29	22510
....	.....	.....	2000	13.33	23850
....	.....	.....	2100	13.37	25190
....	.....	.....	2200	13.41	26530

TABLE 2
Five-point Lagrangian Interpolation Coefficients for Interpolating Values from the Kelvin Scale to the Rankine Scale

For the Value at T°R.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.
500	+0.770421	273.16	+0.251065	300	−0.028976	400	+0.008911	500	−0.001422	600
520	+0.327071	273.16	+0.707135	300	−0.045503	400	+0.013401	500	−0.002104	600
537	+0.045230	273.16	+0.963183	300	−0.011047	400	+0.003117	500	−0.000482	600
600	+0.453090	300	+0.904821	400	−0.543055	500	+0.226280	600	−0.041145	700
700	+0.033745	300	+1.080450	400	−0.162014	500	+0.056844	600	−0.009643	700
800	−0.040909	300	+0.533183	400	+0.637471	500	−0.151857	600	+0.023100	700
900	+0.000000	300	+0.000000	400	+1.000000	500	+0.000000	600	+0.000000	700
1000	−0.036301	400	+0.406359	500	+0.763296	600	−0.156465	700	+0.023111	800
1100	+0.008629	400	−0.065583	500	+0.984637	600	+0.081961	700	−0.009643	800
1200	−0.028781	500	+0.287722	600	+0.854463	700	−0.143999	800	+0.020565	900
1300	+0.015636	500	−0.113725	600	+0.939002	700	+0.178628	800	−0.019540	900
1400	−0.019540	600	+0.178627	700	+0.939002	800	−0.113725	900	+0.015636	1000
1500	+0.020565	600	−0.143999	700	+0.854463	800	+0.287722	900	−0.028781	1000
1600	−0.009643	700	+0.081961	800	+0.984637	900	−0.065583	1000	+0.008629	1100
1700	+0.023111	700	−0.156465	800	+0.763296	900	+0.406359	1000	−0.036301	1100
1800	+0.000000	800	+0.000000	900	+1.000000	1000	+0.000000	1100	+0.000000	1200
1900	−0.036301	900	+0.406359	1000	+0.763296	1100	−0.156465	1200	+0.023111	1300
2000	+0.008629	900	−0.065583	1000	+0.984637	1100	+0.081961	1200	−0.009643	1300
2100	−0.028781	1000	+0.287722	1100	+0.854463	1200	−0.143999	1300	+0.020565	1400
2200	+0.015636	1000	−0.113725	1100	+0.939002	1200	+0.178628	1300	−0.019540	1400
2300	−0.019540	1100	+0.178628	1200	+0.939002	1300	−0.113725	1400	+0.015636	1500
2400	+0.020576	1100	−0.144033	1200	+0.864197	1300	+0.288066	1400	−0.028807	1500
2500	+0.008637	1100	−0.052837	1200	+0.168420	1300	+0.898237	1400	−0.022455	1500
2600	−0.035325	1100	+0.204745	1200	−0.519737	1300	+1.126099	1400	+0.225220	1500
2700	+0.000000	1100	+0.000000	1200	+0.000000	1300	+0.000000	1400	+1.000000	1500

TABLE 3

Five-point Lagrangian Interpolation Coefficients for Interpolating Values from the Kelvin Scale to the Centrigrade Scale

For the Value at t°C.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.
18	+0.245864	273.16	+0.784647	300	−0.040456	400	+0.011790	500	−0.001844	600
25	+0.045230	273.16	+0.963183	300	−0.011047	400	+0.003117	500	−0.000482	600
100	+0.105168	300	+1.146657	400	−0.363958	500	+0.135674	600	−0.023541	700
200	+0.105168	400	+1.146657	500	−0.363958	600	+0.135674	700	−0.023541	800
300	+0.017970	300	−0.113391	400	+0.402572	500	+0.731549	600	−0.038700	700
400	+0.017970	400	−0.113391	500	+0.402572	600	+0.731549	700	−0.038700	800
500	+0.017970	500	−0.113391	600	+0.402572	700	+0.731549	800	−0.038700	900
600	+0.017970	600	−0.113391	700	+0.402572	800	+0.731549	900	−0.038700	1000
700	+0.017970	700	−0.113391	800	+0.402572	900	+0.731549	1000	−0.038700	1100
800	+0.017970	800	−0.113391	900	+0.402572	1000	+0.731549	1100	−0.038700	1200
900	+0.017970	900	−0.113391	1000	+0.402572	1100	+0.731549	1200	−0.038700	1300
1000	+0.017970	1000	−0.113391	1100	+0.402572	1200	+0.731549	1300	−0.038700	1400
1100	+0.017970	1100	−0.113391	1200	+0.402572	1300	+0.731549	1400	−0.038700	1500
1200	−0.038700	1100	+0.211469	1200	−0.500390	1300	+0.789571	1400	+0.538049	1500

TABLE 4

Five-point Lagrangian Interpolation Coefficients for Interpolating Values from the Kelvin Scale to the Fahrenheit Scale

For the Value at t°F.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.	Multiply	By the Value at T°K.
60	+0.327071	273.16	+0.707135	300	−0.045503	400	+0.013401	500	−0.002104	600
77	+0.045230	273.16	+0.963183	300	−0.011047	400	+0.003117	500	−0.000482	600
100	+0.799037	300	+0.387600	400	−0.273868	500	+0.119423	600	−0.022182	700
200	+0.144937	300	+1.152215	400	−0.433764	500	+0.165335	600	−0.028940	700
300	−0.035422	300	+0.784285	400	+0.332766	500	−0.097176	600	+0.015554	700
400	−0.019712	300	+0.180450	400	+0.937934	500	−0.114414	600	+0.015742	700
500	+0.020570	300	−0.143699	400	+0.865575	500	+0.286280	600	−0.028673	700
600	+0.006760	300	−0.053708	400	+0.171053	500	+0.895522	600	−0.022627	700
700	+0.023096	400	−0.156424	500	+0.764612	600	+0.404939	700	−0.036228	800
800	+0.000144	400	−0.000866	500	+0.002900	600	+0.998553	700	−0.000432	800
900	+0.023136	500	−0.152104	600	+0.640121	700	+0.529703	800	−0.040856	900
1000	+0.008513	600	−0.064749	700	+0.985081	800	+0.080652	900	−0.009498	1000
1100	+0.020635	600	−0.132114	700	+0.496201	800	+0.656467	900	−0.041189	1000
1200	+0.015554	700	−0.113190	800	+0.939822	900	+0.177222	1000	−0.019408	1100
1300	+0.015742	700	−0.098421	800	+0.337869	900	+0.790514	1000	−0.035704	1100
1400	+0.030570	800	−0.143699	900	+0.865575	1000	+0.286280	1100	−0.028673	1200
1500	+0.006760	800	−0.053708	900	+0.171053	1000	+0.895522	1100	−0.022627	1200
1600	+0.023096	900	−0.156424	1000	+0.764612	1100	+0.404949	1200	−0.036228	1300
1700	+0.000144	900	−0.000866	1000	+0.002900	1100	+0.998553	1200	−0.000432	1300
1800	+0.023136	1000	−0.152104	1100	+0.640121	1200	+0.529703	1300	−0.040856	1400
1900	+0.008513	1100	−0.064749	1200	+0.985081	1300	+0.080652	1400	−0.009498	1500
2000	+0.020635	1100	−0.132114	1200	+0.496201	1300	+0.656467	1400	−0.041189	1500
2100	−0.019401	1100	+0.112594	1200	−0.307270	1300	+1.133901	1400	+0.080170	1500
2200	−0.035704	1100	+0.194262	1200	−0.455462	1300	+0.694910	1400	+0.601994	1500

$$C^\circ_p =$$
$$(0.008513)\ (11.68) - (0.064749)\ (12.13)$$
$$+$$
$$(0.985081)\ (12.46) + (0.080652)\ (12.71)$$
$$-$$
$$(0.009498)\ (12.91) = 12.49 \text{ Btu/lb-mole-°F}$$

Fortunately, the numerical values of heat capacity and entropy are the same on all temperature scales so the appropriate set of units may be written down immediately. For enthalpy, the units cal/g-mole are equal to Pcu/lb-mole, which must be multiplied by 1.8 to give Btu./lb-mole. Thus at 1500° F. (1088.72° K.), T_1 is selected as 800 and T_2 as 1200° K. At 1500° F.:

$$H^\circ =$$
$$(0.00860)\ \ (5891) - (0.053708)\ (7150)$$
$$+$$
$$(0.171053)\ \ (8431) + (0.896522)\ (9729)$$
$$-$$
$$(0.022627)\ (11040) = 9583 \text{ cal/g-mole}$$
$$= 9583 \text{ Pcu./lb.-mole}$$

$$H^\circ =$$
$$(9583)\ (1.8) = 17{,}250 \text{ Btu./lb.-mole}$$

It is regrettable that so many of the scientists who calculate thermodynamic functions start at 298.16° K. (25° C.) rather than at 273.16° K., the ice point, which serves as a basic reference point for relative enthalpy. The value at 25° C. or 77° F. can be calculated readily using the interpolation formula. If the ice point value is not given, it can be obtained by calculation using the methods of statistical mechanics. The engineer will more frequently use a method of graphical extrapolation or an extrapolation formula such as the Gregory backward formula.[1] In a test of this equation using five known heat capacity values from 300° to 700° K. the value calculated for 273.16° K. checks within a few hundredths of the value calculated by statistical mechanics except when the value of the function drops rapidly below 300° K. as does occur with some molecules.

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Special Muffles Manufactured For Big Catalytic Cracker

DRILLING holes in one of three novel, internal heads especially designed by The M. W. Kellogg Company, refinery and chemical engineers of New York, for huge muffler which will be used in the exhaust stack of the Fluid catalytic cracker with the world's largest reactor-thruput. Measuring almost nine feet in diameter, three of these heads will be placed in tiers within the stack atop the regenerator section of Gulf Oil Corporation's new 60,000 barrel-per-day cracker at Port Arthur, Texas. The muffle heads, fabricated in Kellogg's Jersey City works, are designed to eliminate the roar of escaping, high-velocity flue gases produced during the high-temperature regeneration of catalyst.

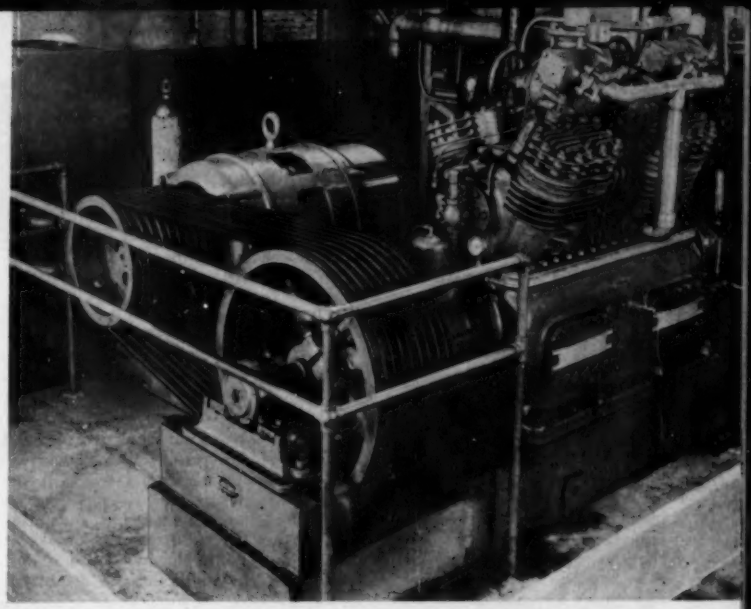


Figure 1. Reciprocating compressor typical of units used for process and air conditioning loads. This neat installation is conveniently arranged for inspection and operation.

REFRIGERATION
In the Refining Industry

PART II

TYLER G. HICKS
Mechanical Engineer, New York

THE FIRST article in this series discussed the elements of refrigerating systems used in refining and petrochemical operations. This, Part II, will consider typical applications in various phases of modern refining and petrochemical processes. In each example cited, the underlying reasons for use of a particular system will be given. With these facts in mind designers and process plant operators will be better able to select and care for the refrigerating systems needed in their plants.

DEWAXING, alkylation (both the sulphuric and hydrofluoric acid processes), light-end recovery, lean oil cooling, reaction heat control, chemical synthesis, gas recovery, gas dehydration, and liquid gas storage are a few of the major applications of refrigeration in refinery and petrochemical plants. To see how refrigeration tonnage is computed for these and other process loads, let's take a look at a typical dewaxing problem.

Illustrative problem: Seven hundred and fifty gallons of distillate are to be cooled per hour from 90° to 30° F. and 15 percent of wax by weight is to be removed. What refrigeration tonnage is required if the specific heat of solid wax is 0.6, specific gravity of the oil 0.85, specific heat of oil 0.5, latent heat of fusion of wax 125 Btu. per pound, and wax separation begins at 65° F.?

Solution: Weight of oil cooled per hour is 750 (8.33) (0.85) = 5,310 pounds. To reduce oil temperature from 90° to 65° F., 0.5 (5,310) (90 — 65) = 66,375 Btu. must be removed. To freeze the wax, 0.15(5,310) (125) = 99,565 Btu.; to reduce wax temperature from 65° to 30° F., 0.15(5,310) (65 — 30) = 27,900 Btu.; to reduce oil temperature to 30° F., (1.00 — 0.15) (5,310) (65 — 30) (0.5) = 79,000 Btu. Total heat to be removed per hour is the sum of these quantities, or 272,840 Btu. Neglecting losses in piping and compressor, tonnage required is 272,840/12,000 Btu. per hour per ton = 22,8 tons.

Production Processes

A) Dewaxing. Both ammonia and hydrocarbon refrigerants have been used in dewaxing operations. When ammonia is used, reciprocating compressors are generally employed in conjunction with a brine system. Direct expansion systems are not extensively used at present. Ammonia compressors used in dewaxing conform to usual design and operating characteristics for this type unit, as does the brine system.

Within recent years centrifugal compressors have been installed for many dewaxing jobs. Using a hydrocarbon refrigerant, such as propane, and two stages of flash cooling, power required for these units equals that of ammonia practice. Since there is no internal lubricant used in centrifugal compressors, less heat exchanger maintenance is required because surfaces do not become fouled. Besides, propane gas has a lower discharge temperature, producing less scale formation in condensers.

B) Alkylation. Compression systems are most extensively used for sulphuric acid and hydrofluoric processes. Propane is the refrigerant used in the former and butane in the latter. Since large volumes of gas must be handled in compressors which are preferably uncooled, centrifugal units are much favored for this work. High cycle efficiencies have been obtained with these units, especially when interstage flash cooling of the refrigerant has been applied. Reciprocating compressors have been successfully applied for this work when gas volumes handled were small or moderate but large volumes indicate use of centrifugal units. In addition, reduction of heat exchanger fouling is advantageous from the maintenance standpoint.

C) Light-End Recovery. Reciprocating compressor systems for light end recovery have found many applications. With the usual refrigerants available, cascaded circuits are generally necessary when exceptionally low temperatures are used in the process. Under such conditions, lubrication and suction valve regulation sometimes become serious operating problems. However, with modern units and lu-

bricants, these problems can be satisfactorily solved.

To eliminate cascading and utilize industry products, some refiners have adopted centrifugal compressors for lean oil cooling work. These units use ethane or ethylene in the low temperature cycle. Large volumes of vapor are handled in large capacity compressors. Usually, fewer centrifugal compressors are required than reciprocating units. Temperatures below minus 150° F. have been used in some lean oil cooling applications.

D) Reaction Heat Control. Exothermic reactions such as those encountered in polymerization and alkylation often require refrigeration for control of reaction heat. Absorption, reciprocating or centrifugal units can be used for this work, according to plant economics. Hydrocarbon refrigerants have been used with centrifugal compressors while ammonia is the most common refrigerant used in reciprocating and absorption units.

In applying any type unit to reaction-heat-control operations, one of the principal requirements is accurate temperature regulation. Means used to regulate temperature vary with compressor type and reaction served. Variable speed drives, suction pressure regulators, and refrigerant gas bypasses are all used singly or in combination for temperature control.

E) Chemical Synthesis. Where reciprocating compressors are used in chemical synthesis, several are usually required because refrigeration loads are large and variable. There are many such installations in operation at present. Where absorption or centrifugal units are used, one or two can usually carry the refrigeration loads encountered in processes such as production of butadiene. Ammonia is the refrigerant commonly used in reciprocating and absorption systems; petroleum or halogenated hydrocarbons are applied with centrifugal compressors.

Air Conditioning

Refrigeration applied to air conditioning units in refining and petrochemical plants aids in control of two factors important to human comfort; temperature and humidity. Although not of major importance in eastern and middle west process plants, air conditioning has found widespread uses in southern and southwestern plants. Foreign plants in equatorial climates have also made extensive use of air conditioning in control rooms, offices, and other heavily populated areas.

As often applied to air conditioning systems, refrigeration units cool water in a shell-and-tube type heat exchanger. This cool water is then pumped to the conditioning unit where it reduces the temperature of the air passing over it. The air is humidified or dehumidified during passage through the conditioner, according to desired atmospheric conditions in the space.

Besides chilled water, either brine or a refrigerant may be used in the conditioner. When a refrigerant is used, it is expanded directly into the coils of the conditioner. With brine, a cooler is used and the brine circulated through the coils in the conditioner.

Compressors applied to air conditioning loads are usually either of the reciprocating or centrifugal type. As a general rule, reciprocating compressors are applied most frequently to small and medium sized air conditioning loads. Large loads are handled today by centrifugal compressors using any one of the newer refrigerants. Absorption refrigerating systems can be and have been applied to air conditioning systems. In general, however, reciprocating and centrifugal units are applied more frequently at present.

Air Supply

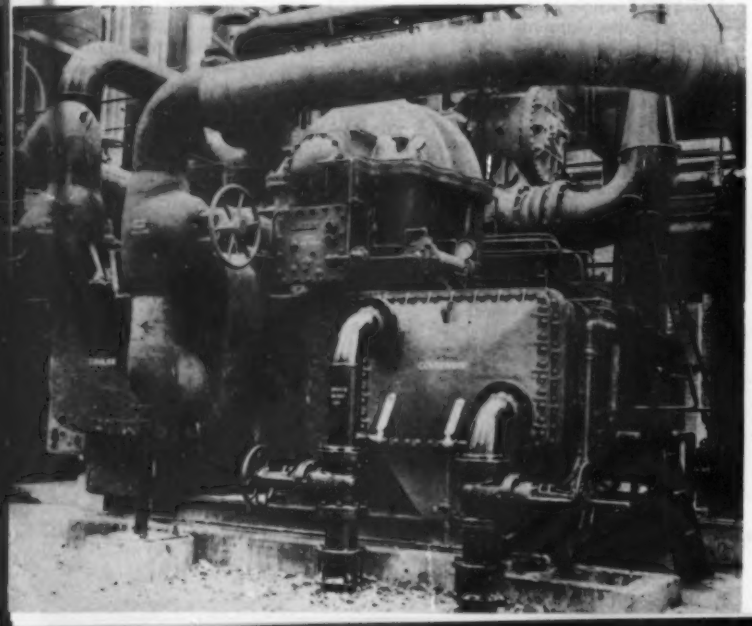
Air supplied conditioned spaces flows through ducts from the conditioner and is distributed to various rooms. Patented air diffusers are generally used to distribute the air uniformly throughout the rooms. These may be located either in the ceiling or on the wall. When air is returned to the conditioner, after its temperature and humidity have changed in the room, return grilles are also fitted in the room. Alternatively, the conditioned air may be allowed to exhaust to the atmosphere after use.

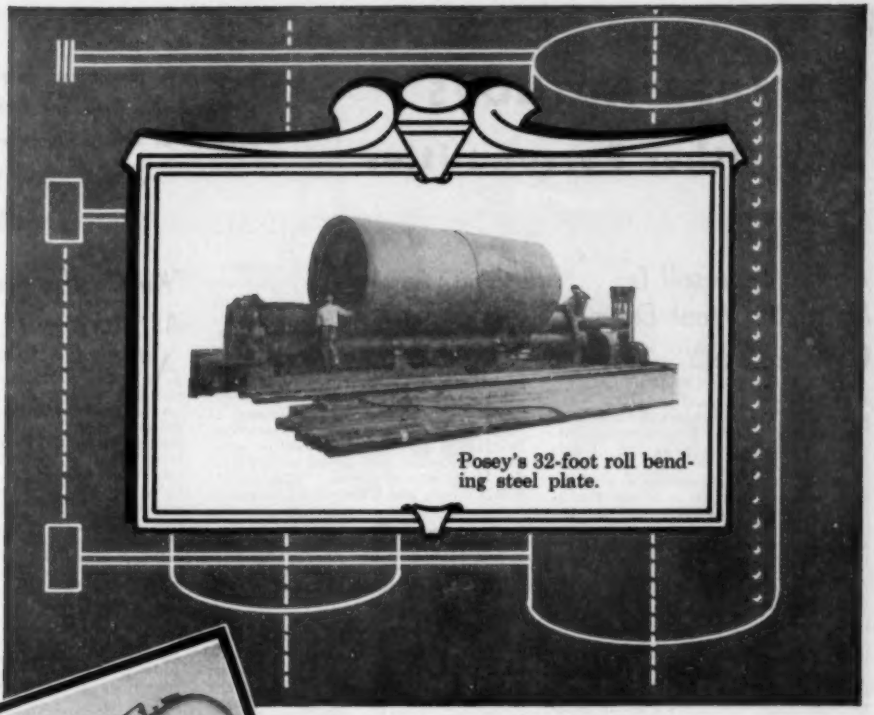
Refiners have found that air conditioned work spaces are a good investment, particularly in hot humid climates. Employe efficiency, satisfaction, and loyalty are increased by the better working conditions obtainable. Where large employe groups are concentrated indoors in warm climates, air conditioning can usually be justified. With small employe groups, installation of air conditioning equipment is usually directly dependent upon general weather conditions in plant locality and their effect upon employes. Low cost unit or room conditioners can often be installed for isolated rooms where central systems are not justifiable.

One advantage of air conditioning systems which should not be overlooked during process plant design is the fact that the same system can be used summer and winter. By installing steam heating coils in the conditioner, outside air can be heated during winter months and distributed through the same ducts used for conditioned air. Piping and radiator or unit heater costs are thereby reduced. When this summer-winter feature is taken into account it is often possible to justify an air conditioning system where it would not otherwise be possible to do so.

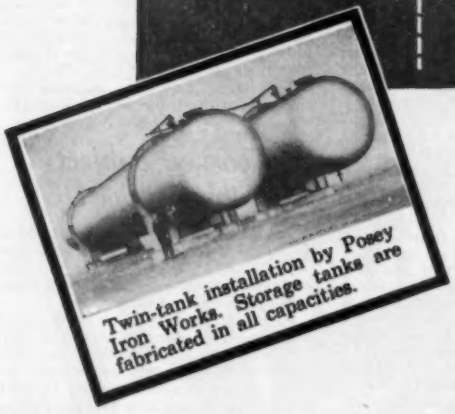
End Part II. Part III will appear in an early issue.

Figure 2. Two of four centrifugal refrigerating machines used to remove reaction heat from hydrocarbons and solvents in a Texas butane plant. (Courtesy of Carrier Corporation).





Posey's 32-foot roll bending steel plate.



Twin-tank installation by Posey Iron Works. Storage tanks are fabricated in all capacities.

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REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the industry.

Author Ingersoll Is Instructor Week-Days

ONE of the speakers at the API's Refining division meeting in Tulsa, Alfred C. Ingersoll of the California Institute of Technology at Pasadena, is the author of "The Fundamentals and Performance of Gravity Separation—a Literature Review," on page 106 of this issue.

Dr. Ingersoll, an instructor in civil engineering, is a newcomer to the Pacific Coast. He attended secondary schools in Madison, Wis., and then went on to the University of Wisconsin where his father taught physics for more than 40 years. In 1942 he graduated with a B.S. in civil engineering and then joined Linde Air Products for the remainder of the war years to design and operate portable equipment for producing liquid oxygen for the Navy.

He returned to Wisconsin University in 1946 and taught hydraulics and fluid mechanics, continuing his graduate studies until 1948 he got an M.S. degree and a Ph.D. in civil engineering in 1950. He began his appointment at the California Institute of Technology last September.

Writer Stresses Human Element in Safety Work

HENRY W. BOGGESS, a pioneer in oil industry safety work, is author of "Safety Depends Upon Men Who Carry Its Banner," the article beginning on page 140. Boggess first presented this paper at the Big Spring meeting of the Natural Gasoline Association of America under the title of "Prevention of Accidents in Natural Gasoline Plants."

Boggess, who is now superintendent of Employment-Insurance-Accident Prevention and director of aviation for the Sinclair companies, Tulsa, first joined Sinclair in 1919 after completing service in World War I. He was an organizer and past president of the Oklahoma State Safety Council; past chairman, Petroleum Section, National Safety Council; six years a member of the board of directors and Executive Committee, National Safety Council; and past chairman of the Safety Committee of the American Petroleum Institute. He is presently serving as chairman of the API Natural Gasoline Committee. Boggess is a frequent lecturer on accident prevention and allied subjects at the University of Tulsa, Oklahoma A. & M. College, and Oklahoma University.

Finds Small Time for Small Fry and Golf

TIME-CONSUMING membership in various technical societies and committees keeps Raymond C. Kelly, who wrote the article, "U.S. Industrial Strength May Depend Upon Water Supply," page 75, a comparative stranger to his two hobbies "golf and a two-daughter family."

Kelly got his secondary education in Hinsdale, Ill., and followed high school with two years studying at Purdue before transferring to the University of Arizona where he took a B.S. in mechanical engineering.

Since 1935 he has been busy with industrial refrigeration and air conditioning, working on manufacture and field installation of all types of heat transfer and water conservation equipment. In 1940 he became active in the industrial cooling towers and associated equipment and in 1944 was appointed manager of the Equipment Division of J. F. Pritchard & Company at Kansas City, Mo.

Among the activities that keep him away from the fairway and frolic with his daughters are the A.S.H. & V.E., the Engineers clubs of Kansas City and San Francisco, cooling tower technical committees of the ASME and ACRMA, coupled with the presidency of the Cooling Tower Institute.

"Kirk" Observed Atom At Work—on Bikini

AMONG those scientists who traveled to Bikini Atoll for scientific observation during the Army and Navy tests for "Operation Crossroads" in 1946, was the author of "Houdriforming: A Continuous Process for Reforming Petroleum Naphthas," page 95. **C. G. Kirkbride,** appointed director of Houdry Laboratories in 1947, has published several articles in PETROLEUM REFINER and is well known in chemical circles for his technical books and papers as well as active participation in AIChE. One time professor of chemical engineering at Texas A. & M. College, "Kirk" has had long experience within the oil industry as a member of the staffs of Magnolia Petroleum, Pan American Refining and Standard Oil (Indiana) companies, in addition to his five years at the Houdry laboratory in Marcus Hook, Pa.

Kirkbride took his chemical engineering at the University of Michigan.

VP Learned Subject From the Bottom Up

D. H. PUTNEY, who has been identified with oil refinery design, process and development for the past 27 years, is author of "Alkylation Plant Improvements," on page 89.

Putney is vice president of Stratford Engineering Corporation of Kansas City, Mo., these days, but back in the days just succeeding his graduation from the University of Kansas he went to work for the Sinclair Refining Company doing refinery construction work. By 1925 he had obtained a job with Cross Engineering Company in Kansas City working on design for Cross cracking and distillation units and some of the first tube stills and vacuum units built in U. S.

Alfred C. Ingersoll | H. W. Boggess | R. C. Kelly | D. H. Putney | C. G. Kirkbride

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F. Emerson Ivey, Jr. | R. L. Huntington | J. L. Huitt | William H. Redlien, Jr. | J. H. McClintock

When The M. W. Kellogg Company took over the Cross organization in 1927, Putney was sent to New York to do process design. He remained in the Kellogg organization until 1931 when he joined the Alco Products division of the American Locomotive Company to work on refinery design and engineering in the capacity of chief mechanical engineer.

Some time in 1936 he transferred to Stratford Engineering as chief engineer and became closely associated with alkylation development and correlation. He worked on the design of many of the alkylation units built during World War II. By 1945 he had been appointed technical director of Stratford and in 1950 he became vice president.

Active Hobbies Are Mental Outlet Valve

F. EMERSON IVEY, Jr., author of "Improved Methods for the Particle Sizes Analysis of Fluid-Cracking Catalysts" has been engaged as a catalyst engineer at The Davison Chemical Corporation, Baltimore, since 1948. Prior to that he was an engineer in the Technical Service Division of Gulf Oil Corporation's refinery at Philadelphia.

In 1945, Ivey served on a Catalytic Cracking subcommittee of the Technical Advisory Committee to P.I.W.C. He is also the co-author of the paper "Design and Operation of a Bench-Scale Automatic Catalyst-Aging Unit," which was presented at the 1947 API annual meet.

Born in Bethlehem, Ivey attended nearby Lehigh University and received a B.S. in chemical engineering in 1942. He gained experience in catalytic cracking, alkylation and catalyst testing at his first professional job of chemical engineer at the Refinery Process Section, Gulf Research and Development Company, Harmarville, Pa.

Married and the father of one young Ivey, he shakes off work-day problems when he gets home and turns his hand to cabinetmaking and gardening. He says, "active hobbies act as a release from my daily mental work-outs."

New Hydrocarbon Officer

Malcolm H. Tuttle, formerly vice president of Max B. Miller & Company, Inc., assumed the position of vice president in charge of engineering for Hydrocarbon Research, Inc., last month.

Less Water Pollution Aim of Esso Authors

TWO Esso Standard Oil men conferred and wrote "Reducing Water Pollution for Petroleum Refineries" appearing on page 123. **John H. McClintock** joined Esso in 1930 and now heads a New York staff to coordinate oil losses for Esso and affiliated companies. **William H. Redlien, Jr.,** is associated with Esso's program for pollution control.

Baltimore-born **McClintock** joined Esso as an engineer in the Manufacturing department after attending Johns Hopkins University. Successively he was assigned to refinery process engineering, as a specialist in stock loss control, and to organization and development of Esso's oil conservation program in manufacturing, marketing and distribution fields. In 1948 a central unit to coordinate Esso oil losses was formed and McClintock was named head of the New York staff unit. He has collaborated for numerous articles on stock loss control, and was appointed chairman of the API Advisory Committee on stock loss control in 1950. McClintock takes great interest in civic and community projects and is a member of the Cranford Board of Education, officer of the Cranford Dramatic Club, has served on the Community Chest, and is active in Boy Scout work.

An M.I.T. graduate of 1947 with B.S. and M.S. degrees in Chemical Engineering, **Redlien** joned Esso Standard in 1947 and was assigned to the Technical Service Section of the East Coast Manufacturing Division. Redlien concentrated on operations connected with the chemical products development until 1949 when he was transferred to the company's pollution program. Redlien served with the Chemical Warfare Service in the European theater for three years prior to finishing his schooling.

Chemical Doctors Start Article Series

THIS issue introduces a three part series by **Drs. R. L. Huntington** and **J. L. Huitt,** on "Pressure Drop Through Bubble Caps." Entitled "Introduction and Theoretical Discussion," Part I begins on page 131.

Dr. Huntington is no stranger to PETROLEUM REFINER readers for he has been contributing to this publication for the past 17 years, and is not only a magazine contributor, but a full fledged author since McGraw-Hill published his book, "Natural Gas and Natural Gasoline" in 1950. Before joining the University of Oklahoma staff in 1933, he spent 12 years gaining natural gasoline plant and refining operation and design experience. Dr. Huntington took his graduate work in chemical engineering from M.I.T. and the University of Michigan.

Dr. Huitt who previously taught at Louisiana Polytechnical Institute and Oklahoma University, is currently employed at the Magnolia Petroleum Company Field Research Laboratories, Dallas. During World War II he served three years with the U. S. Army. Dr. Huitt holds the following degrees: B.S. in Ch.E. from Louisiana Polytechnical Institute; M.S. in Ch.E. and a Ph.D. from Oklahoma University.

Cadman Memorial Medal To Be Awarded to Wilson

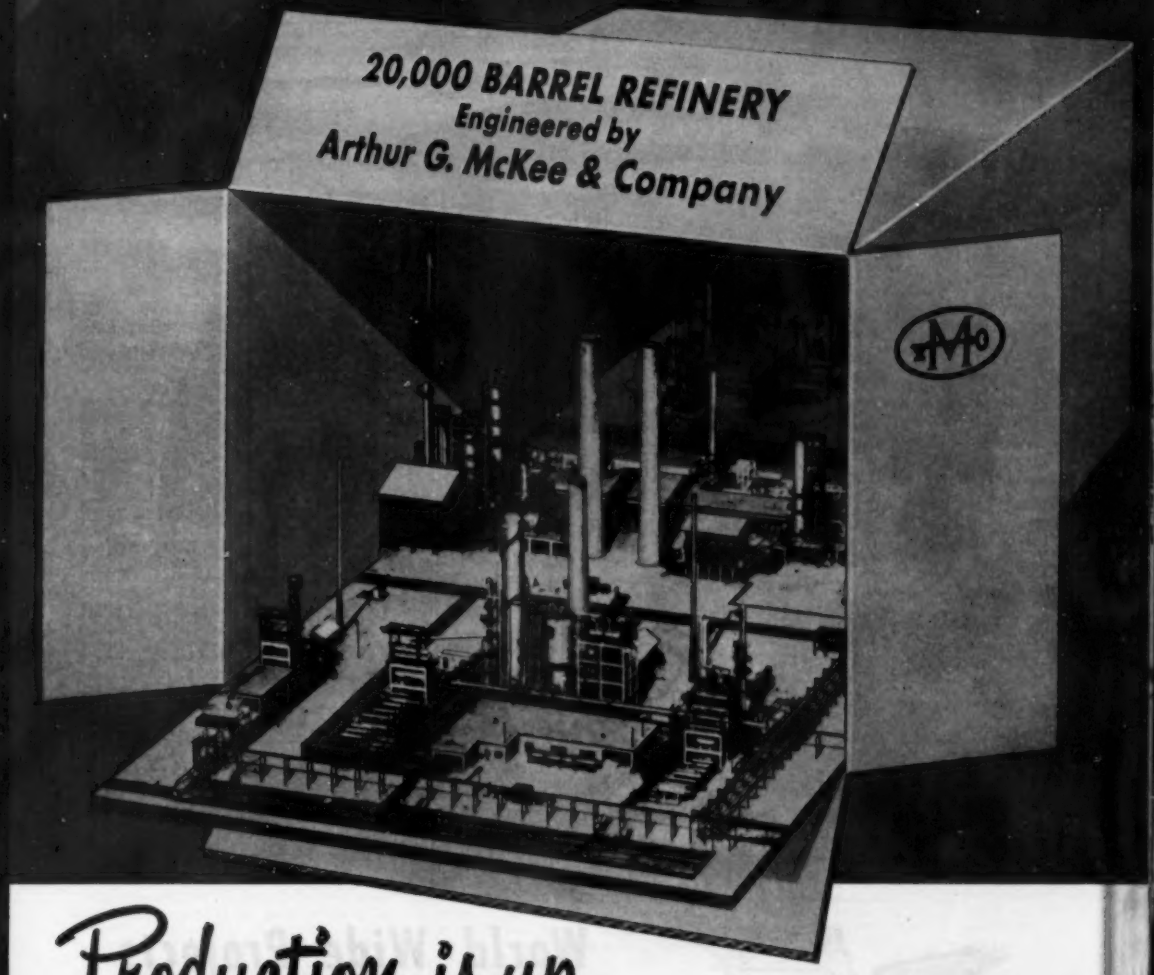
The Council of the Institute of Petroleum has invited Dr. Robert E. Wilson, chairman of the board of Standard Oil Company (Indiana), to deliver the third Cadman Memorial Lecture on June 21, at the Royal Institution, London. C. A. P. Southwell, M.C., president of the Institute of Petroleum will present the Cadman Memorial medal to Dr. Wilson following the lecture.

Dr. Wilson has published more than 80 technical papers and has in excess of 90 patents registered; he received the Chemical Industry medal in 1939 and the Perkins medal in 1949.

Lion Appoints Tallman New Director of Research

Dr. Ralph C. Tallman, formerly manager of the planning and survey department of Lion Oil Company's Research Division since June, 1950, has been named director of research. He replaces Dr. Frank J. Soday, who resigned.

Dr. Tallman was research director for Schieffelin and Company, manufacturers of pharmaceuticals, in New York from 1935 to 1943 and subsequently was project leader and patent chemist in the central research laboratory of Allied Chemical and Dye Corporation at Morristown, N. J.



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The MONTH... in the INDUSTRY

J. R. Haas, general foreman (right) and J. E. Miller, Port Neches plant manager, look at billionth pound. (Story below picture)

Synthetic vs Liquid Fuels Being Studied by Interior

A committee of experts on the production of fuels, created by the Interior Department, reported to the National Petroleum Council that they soon can tell the nearly exact cost and amount of production materials needed for commercial scale production of new liquid and synthetic plants. The Bureau of Mines has contended that synthetic fuel is now almost fully competitive and that synthetic capacity can be developed at lesser costs in materials than natural crude.

Part of the report concerned the cost of exploring for, finding and developing 300,000 barrel-a-day of new crude production capacity in District 3 (Gulf Coast), of providing necessary transportation and of building new refineries to process that crude; costs of a 100,000-barrel-a-day refinery in the Pacific Northwest to run on crude originating in Alberta, Canada, and transported by a new pipe line; cost of a 100,000-barrel-a-day refinery for Venezuelan crude to be located on the East Coast.

An economics subcommittee is making a "dry-run" test involving economic calculation of costs of building a theoretical 30,000-barrel-a-day coal hydrogenation plant to be located at Rock Springs, Wyo., a site long advocated by the Bureau of Mines.

Certain private interests believe they could put up $200 to $400 million to launch a commercial production of synthetic liquid fuels from coal, provided the government gives them a market, according to Interior Secretary Oscar Chapman. He emphasized that such construction would be strictly a private project, and that he did not propose that the government move into either coal or shale production.

However, he said that shale production could be expanded more quickly and cheaply than the production of liquid fuels from coal and expressed the thought that "oil shale might be our best insurance" for quick expansion to overcome some unexpected gasoline supply emergency.

Lander Elected President At LPGA Annual Convention

New president of Liquefied Petroleum Gas Association, William S. Lander, president of Rulane Gas Company, Charlotte, N. C. was elected at the annual meeting in Chicago in May. He succeeds Peter A. Anderson, President of Utilities Distributors, Inc., Portland, Me.

Other newly elected officers are F. N. Mabee, president of Colorado Natural Gas & Fuel Company, Denver; C. M. Ambrose, Jr., president of Liquefied Petroleum Gas Corporation, Seattle; and Walter Miller, president of Dri-Gas Corporation, Chicago. Reelected were Howard D. White and Arthur C. Kreutzer, both of Chicago.

Industry section chairmen include: Marketers, Walter A. Schuette, Hausgas, Inc., Washington, Mo.; Appliance Manufacturers, George H. McFadden, Ohio Foundry & Manufacturing Company, Steubenville, Ohio; Equipment Manufacturers, Fred A. Henninger, Charlotte Tank Company, Charlotte, N. C.; Producers, H. W. Rigterink, Sun Oil Company, Philadelphia, Pa.; Utilities, Charles E. Tenney, Willmar Gas Company, Willmar, Minn.; International, Charles W. Bonar, Tappan Stove Company, Mansfield, Ohio.

Sixth Coal Hydrogenation Test-Run Results Told

A shipment of 2600 tons of coal yielded nearly 8000 barrels of synthetic oil, or 3.7 barrels of oil per ton of moisture-free coal, in a two-month experimental run at the Coal-Hydrogenation Demonstration Plant of the Bureau of Mines, Louisiana, Mo. Synthetic gasoline processed from the plant has been undergoing extensive tests by the armed forces, government officials said.

As a result of previous test runs many improvements and refinements have been made. One processing feature "of significant value in conserving strategic materials for defense use" was the substitution of a highly efficient and cheap iron catalyst for scarce tin catalyst. Mechanical improvements tested during the sixth run included a change to welded hot pipe construction in the converter stalls, reduction in converter volume, the use of a new type spring-loaded and lubricated injection pump packing, and the use of new valve material more resistant to erosion.

Complete operating data have not been compiled but Bureau reports that the Kentucky coal showed a high degree of liquefaction at a conversion pressure of 7700 psi, and at a temperature of 875° F. with a hydrogen partial pressure of 6100 psi.

Named Project Engineer

Leo A. Castler has been promoted to project engineer in the Engineering Department of General Petroleum Corporation. Castler will report to the company's Vernon, Calif., offices.

Billion Pounds of Rubber Synthesized in 8 Years

A billion pounds, or 500 thousand tons of American rubber has been produced during the past eight years at the government's Port Neches, Texas, synthetic rubber plant operated by B. F. Goodrich Chemical Company. The Port Neches installation produced its first pound on August 18, 1943 and continued production after the war when most other government rubber plants were put on a standby basis. Its rated capacity is 60,000 long tons per year. See photo above.

B. F. Goodrich Chemical Company recently reactivated the huge 90,000-long-ton-pear-year Institute, W. Va., GR-S plant.

Phillips Opens Way to Expanded Rubber Capacity

A new development in synthetic rubber production, announced by Phillips Petroleum, is said to increase production capacity from 20 to 50 percent. The device recently perfected by Phillips engineers is a method of inserting cooling coils in the present reactors to remove the heat faster. Up to this point it has been impossible to take advantage of superfast reactions in production because plant equipment could not remove the great amount of heat generated. On plant-scale runs at the Phillips-operated and government-owned synthetic rubber plant at Borger, Texas, rubber is now made in 8 hours instead of 12 or 14.

Four Technicians Added Houdry Process Staff

Houdry Process Corporation has added four men to its staff. Erich R. Westfield, formerly with Pan American Refining Corporation, and a graduate of Vanderbilt University and Massachusetts Institute of Technology, has been assigned to the economic and correlation section of the Research and Development division. Gerald J. Orazem, assigned to the same department, is a recent graduate of the University of Minnesota.

H. Harold Bulkowski joined the Development department and is assigned to the Atomic Energy Commission program. Formerly with Battelle Memorial Institute, he is a graduate of Carnegie

The MONTH . . .

Institute of Technology and Ohio State University. Dr. William E. Erner, a Notre Dame Ph.D., is now a member of the exploratory research group of the Research and Development division.

THE OIL MAN'S CALENDAR

JUNE	
11–15	American Society of Mechanical Engineers, Semi-Annual, Toronto, Royal York Hotel.
14–15	Pennsylvania Grade Crude Oil Association, Annual Meeting, Pittsburgh, Hotel William Penn.
18–22	American Society for Testing Materials, Annual Meeting, Atlantic City, N. J.
28–29	LP-Gas Management Conference, Lafayette, Ind., Purdue University.
JULY	
9–21	Summer Laboratory Course, "Techniques and Applications of the Electron Microscope," Laboratory of Electron Microscopy, Rockefeller Hall, Cornell University, Ithaca, N. Y.
19–20	WPRA Regional, Wichita, Broadview Hotel.
AUG.	
17	WPRA Regional, Alma, Mich., Leonard Refineries, Aud.
13–14	LP-Gas Engine Fuel School, Lafayette, Ind., Purdue University.
SEPT.	
3– 7	American Chemical Society, Annual, N.Y. Hotel Statler. 120th Nat'onal Diamond Jubilee.
10–14	Instrument Society of America, Sixth National Instrument Conference and Exhibit, Houston, Sam Houston Coliseum.
11–13	Interr ational Discussion on Postwar Heat Transfer Development with ASME Administrative Coordinator, London.
12–14	National Petroleum Association, Atlantic City, N. J., Hotel Traymore.
16–19	American Institute of Chemical Engineers, Regional Meeting, French Lick, Ind. and Rochester, N. Y., Sheraton Hotel.
20–21	WPRA Regional, Casper, Wyo., Hotel Henning.
25–28	American Society of Mechanical Engineers, Fall, Minneapolis, Minn., Hotel Radisson.
OCT.	
4– 5	California Natural Gasoline Association, 26th Annual, Los Angeles, Ambassador Hotel.
8– 9	Texas Mid-Continent Oil & Gas Association, Annual, Beaumont, Texas, Hotel Beaumont.
8–10	The American Oil Chemists' Society, Fall, Chicago, Edgewater Beach Hotel.
8–12	National Safety Council, 39th National Safety Congress and Exposition, Chicago, Stevens Hotel.
14–20	Oil Progress Week.
15–17	American Gas Association, Annual, St. Louis, Kiel Auditorium.
18–20	National Association of Corrosion Engineers, South Central Region, Corpus Christi, Texas.
22–24	American Standards Assn., Annual, New York, Waldorf-Astoria Hotel.
NOV.	
5– 8	American Petroleum Institute, Annual Convention, Chicago, Stevens Hotel.

Burns Heads Underground Oil Storage Committee

A 19-member committee appointed by National Petroleum Council Chairman Walter S. Hallanan to investigate feasibility of underground storage for refined products, including LP gas, is headed by H. S. M. Burns, of Shell Oil Company.

Other members of the committee are: H. T. Ashton, WPRA; Rush M. Blodget, Oil Producers Agency of California; William R. Boyd, Jr., Boyd, Hardey & Wheelock; Ralph K. Davies, American Independent Oil Company; E. DeGolyer, DeGolyer and MacNaughton; Warwick M. Downing, Denver; J. Frank Drake, Gulf; R. G. Follis, California Standard; Jake L. Hamon, Mid-Continent Oil and Gas Association; Eugene Holman, Jersey Standard; Harry Leyendecker, Independent Refiners Association of America; Joseph E. Pogue, Chase National Bank, New York; Sid W. Richardson, Fort Worth; A. S. Ritchie, Wichita, Kan.; Clarendon E. Streeter, Pennsylvania Grade Crude Oil Association; W. K. Warren, Warren Petroleum; L. S. Wescoat, Pure; W. S. Zehrung, National Petroleum Association.

40 Percent Fuel Economy Cited for "19XX" Engine

A 29 to 40 percent gain in fuel economy was reported for the new 12-to-1 compression ratio V-8 experimental engine, designated 19XX, over standard 1951 engines of 7.5-to-1 compression ratios in a Cadillac road test run last winter by General Motors at Phoenix. A GM executive reported the results of the tests before an API Refining Division meeting, and said further that the 19XX motor showed a steady gain in economy of nearly 40 percent over the 1951 car when both cruised at 40 mph.

He reported that higher octane fuel than is commercially available today and an improved hydra-matic transmission were coupled with the 12-to-1 compression ratio to produce better fuel mileage in the 19XX car. The octane rating used was computed to be equivalent to about 103 octane number.

Bartlesville Personnel Promoted at Phillips

Personnel changes effected by Phillips Petroleum Company include:

W. H. Creel, formerly in charge of the Refining Department's engineering, planning and development, has been appointed assistant manager. He will report to C. C. Tate, who recently was made manager of the Refining Department. Creel will have charge of all manufacturing and engineering activities carried on in Bartlesville.

W. A. McCarthy, superintendent of the Kansas City, Kans., refinery for the past four years, has been appointed staff assistant to the manager, with his office in Bartlesville. Succeeding McCarthy, is H. G. Fair, who was assistant superintendent of the Kansas City refinery. L. G. Molique, until recently in charge of planning and development in the aviation fuels division in Bartlesville, has been named assistant superintendent of the Kansas City refinery.

Shell Promotes Randlett

A Shell Development veteran of ten years, Herbert E. Randlett, Jr., has been named technical representative in the New York office to replace Harry K. Sutherland who has been transferred to the company's Agricultural Laboratory at Modesto, Calif. Randlett joined Shell in 1939 as a chemist at Martinez, Calif., and was transferred to San Francisco as an engineer in 1943. He was named administrative assistant to the director of research at the Emeryville laboratories in 1950.

Chicago Section of SAE Announces New Officers

New chairman of the Chicago section of the SAE is J. E. Kline, head of the Stan-Add additive division of Standard Oil Company's sales technical service department. He succeeds T. A. Scherger of the Studebaker Corporation at South Bend, Ind., as chairman.

Kline

Other officers for the Chicago section during the 1951-52 season include Robert C. Wallace, Diamond T. Motor Car Company, vice chairman; Lloyd F. Overholt, International Harvester Company, secretary; and David C. Peterson, Stewart-Warner Corporation, treasurer.

Chapman Promises Aid In Securing Oil Materials

The National Petroleum Council was advised by Secretary of Interior Oscar Chapman that he will attempt to procure every bit of materials the oil industry needs to get its mobilization job done. In his opinion, he said, the public relations of the oil industry is in best shape ever, the industry has achieved a proud record, and he himself has learned to like and respect the industry in spite of his earlier suspicions.

He told the NPC that he was renewing efforts to break the Justice Department's stalemate requiring government employes to head defense advisory committees, and still hopes to clarify the council's status.

Apparatus Tests Lubricant Changes Under Pressure

Socony-Vacuum Oil Company, Inc., has disclosed a method for determining the effectiveness of lubricants at pressures previously impossible to measure with scientific accuracy in ultra-thin films. Essentially the new measuring apparatus developed at Socony's Paulsboro laboratories, is a vertical and a horizontal steel cylinder, each cylinder a quarter-inch in diameter, oriented at right angles to each other. The horizontal cylinder is maintained in a fixed position while the vertical one is capable of being rotated under pressure or for exertion of direct pressures up to 250,000 psi. at the contact point

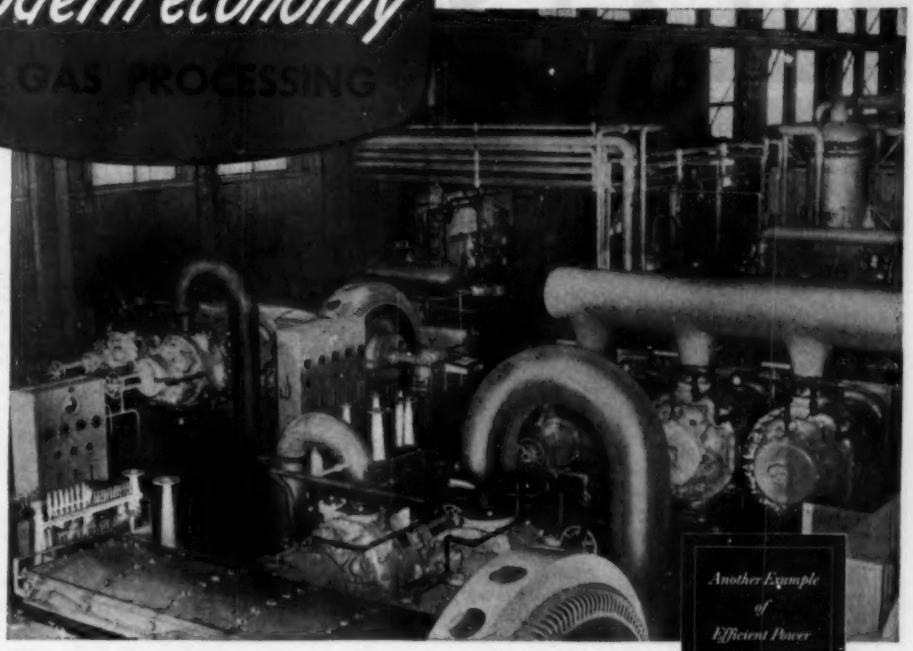
Gauges connected with the instrument provide readings on the force of the drive, extent of loading at the oil-filmed contact point, and the amount of torque present when the instrument is in operation.

The effectiveness of various lubricants under test is measured after each operation of the instrument by microscopic examination of wear on the cylinders at their contact point or the depth of a pit created in the fixed cylinder after the upright cylinder has been rotated against it.

The instrument in addition to lubricant studies, "has important potentialities for determining the point at which films of solids such as soap will break down and permit contact between two surfaces under extreme pressure," and aids also in measuring "the importance

modern economy

IN GAS PROCESSING



Another Example of Efficient Power at Lower Cost

Cooper-Bessemer motor-driven JM compressors

● These 3 Cooper-Bessemer JM motor-driven compressors are busy saving dollars month in, month out in one of the nation's biggest ammonia producing plants.

If you wonder where the unusual economy comes in, the answer is quite simple. Because these JM's are exceptionally compact, without sacrificing accessibility or ruggedness, they conserve costly space, require less investment in foundations, piping and over-all installation requirements.

Moreover, it's demonstrated time and again that these modern, compact Cooper-Bessemer compressors retain the long life qualities of the much bigger slow speed units. Naturally this adds up to low upkeep cost on any long range basis you care to name.

If your plans call for motor-powered compressor service, up to 3000 hp, let us give you some interesting facts on the Cooper-Bessemer features ready to save you money year in, year out.

The Cooper-Bessemer Corporation

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A portable R-C Inert Gas Generator used for purging operations and stand-by protection in large gas-producing plant. Capacity 15,000 cfh.

Today's urgent production demands can tolerate no unwarranted risk of interruption by explosions which might cause even small fires or other plant damage. Against such hazards, R-C Inert Gas Generators provide positive, economical protection.

This protection is essential in plants where inflammable gases, liquids, explosive dusts and other dangerous materials are handled, processed or stored. Available either in stationary or mobile units, R-C Inert Gas Generators greatly reduce the risks from fires caused by explosions. They are compact, simple and sturdy in construction and operate at extremely low cost. Available in capacities from 1,000 to 35,000 cfh.

If your operations involve materials or processes which might cause explosion-produced fires, investigate the protection afforded by R-C Inert Gas Generators. Installation costs in many cases can be offset by insurance savings. Ask us for details.

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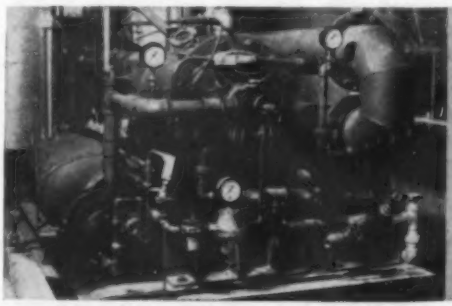

Installation of three R-C Inert Gas Generators similar to this one helped one large plant save $6,000 per month insurance premiums, as well as substantially reduce danger of production losses caused by explosion or fires. Capacity of each unit, 6,000 cfh.

ROOTS-CONNERSVILLE

BLOWER BUILDERS SINCE 1854

ONE OF THE DRESSER INDUSTRIES

The MONTH...

of temperature to maintenance of the shear strength of a film of grease or oil."

Navy Initiates Fuels Experiments at Annapolis

Because facilities for testing fuels and lubricants had mushroomed up in various parts of the Naval Engineering Experiment Station at Annapolis, a new Fuels and Lubricants project has been established to test and develop engineering equipment for use in the fleet.

In cooperation with the Defense, Agriculture and Interior departments, and the National Advisory Committee for Aeronautics, etc., the project has undertaken problems involving brand approval tests, performance of high quality lube oils under snorkel submarine conditions, improvement of lube oils for operation in arctic regions, development of fuel type starting aids to perform in internal combustion engines at approximately 65° F. below zero, development of marine gas turbine fuels which are economical and plentiful, and development of lubricants which will operate new types of marine reduction gears.

Harold V. Nutt, a technical assistant and an employe of the Engineering Experiment Station for 13 years, has been appointed superintendent of the Project. He will be assisted by Wilbur E. Robbins, who will head the Fuels Division, and Simon Kremen, former head of the Petroleum Branch in the Station's Chemical Engineering Laboratory and new head of the Lubricants division.

API Reports 8.26 Percent Rise in Gasoline Demand

The API annual survey of gasoline consumption shows domestic demand for gasoline rose 8.26 percent during 1950 to reach an all time high of 40,613,400,000 gallons sold, a demand exceeding by 3 billion gallons the 37,515,278,000 gallons consumed in 1949. Rising gasoline consumption coincided with a sharp rise in automobile registrations.

California led state gas consumption with a sale of 3,854,591,000 gallons; Texas followed with 2,953,511,000 gallons, and New York was third with 2,647,931,000 gallons. Illinois, Ohio, and Pennsylvania also were in the two billion gallon class.

Gasoline production in the United States passed the billion-barrel point for the first time in 1950, totaling 1,024,448,000 barrels and accounting for 43 percent of all refined petroleum products. The peak month for gasoline consumption was August with 3,863,148,000 gallons.

Seven Key Men Promoted By Phillips Chemical

Promotional changes in key personnel for Phillips Chemical Company, wholly-owned subsidiary of Phillips Petroleum Company, announced last month include: W. C. Hewitt, manager, Plains butadiene plant, Borger, Texas, placed on special assignment in connection with the national synthetic rubber program; A. B. Leonard, superintendent, Cactus plant, Etter, Texas, succeeds Hewitt as manager of Plains plant; T. M. Hipp, assistant superintendent at Cactus, succeeds to the superintendent's assignment;

Underground and surface ORE MINED (yearly average—millions of tons)

Underground for Defense

...started more than 10 years ago

STRENGTH...military and economic ...depends on productivity. And productivity depends on men who have devoted long years to their specialized chosen field of endeavour.

Such men with "know-how" mine nickel from the rocky rim of Ontario's Sudbury Basin ...

By increasing output with maximum speed and drawing on reserve stocks of nickel previously accumulated, they helped raise deliveries of nickel in all forms during 1950 to 256,000,000 pounds ... a record for any peace-time year.

This record, 22% greater than the 209,292,257 pounds delivered in 1949, was no accident ...

In 1937, INCO launched a vast long-range project which now makes it possible to meet the military requirements of the United States, Canada and the United Kingdom. In addition, nickel deliveries are being made to government stockpiles and the balance of the supply is being rationed among civilian consumers in all markets throughout the free world.

Since the inception of International Nickel, its fixed policy has always been to increase the supply of nickel. To meet today's needs, INCO went underground years ago.

Anticipating the eventual depletion of Frood-Stobie open pit surface ores, more than 10 years ago, INCO embarked on a program of replacing open pit with underground capacity. This required extensive enlargement of underground plants, development of new methods of mining not previously undertaken and the revamping of metallurgical processes to cope with difficulties in recovering nickel from the new types and lower grades of ores which have to be reached.

Major expansion in output of nickel from underground operations is being driven to conclusion with utmost speed. There is still much construction to be done and a number of mining and metallurgical problems remain to be solved and tested in actual operation. Barring unforeseen interruptions, full conversion to underground mining should be completed in 1953.

When the present undertaking is completed, INCO will be able to hoist 13,000,000 tons annually, and the size of its underground mining operation will surpass that of any other nonferrous base metal mining operation in the world.

This underground expansion is being completed by INCO without interrupting current production of nickel, which is at maximum capacity.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

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PAGE WELDING ELECTRODES

The MONTH . . .

C. W. Foreman, promoted to assistant superintendent from manufacturing superintendent; E. C. Ayres, superintendent, Adams Terminal, Houston, promoted to company's chief process engineer; R. G. Rhodes, formerly process superintendent at Plains plant, succeeds Ayres; A. F. Legatski, formerly process superintendent at Cactus, named superintendent of sulfur plant to be constructed in West Texas.

Brown Says Expand Basic, Military Capacity or Else

Bruce K. Brown, Deputy PAD, told the WPRA in San Antonio at its annual meet, to build the nation's basic refining capacity at a rate that will increase capacity by one million barrels a day in 1953 or the nation will again face shortages that appeared after the last war. He said the million-barrel increase was necessary for peacetime operation and did not take possible impact of war into consideration. He pointed out that business incentive and fast tax write-offs as well as priorities assistance should take care of basic expansion.

PAD will look most favorably on a greater dispersal of refining facilities, he said, indicating that PAD prefers projects to be built in safe interior locations.

If private industry cannot provide special military products, and should Congress so provide, concluded Brown, "we may recommend government-owned plants for such production."

Watson Named Executive VP of Cities Service Oil

Burl S. Watson has been appointed executive vice president and Emil Schram has been named to the board of directors of Cities Service Oil Company.

Watson, a graduate of the University of Alabama in electrical engineering, has been associated with the company since 1917. Schram is former president of the New York Stock Exchange and was at one time chairman of the board of the RFC.

Boron Over-Rated Answer To Low Octane Gasoline

Dr. E. C. Hughes has discounted claims made earlier for the practicality of combining boron compounds with TEL in order to operate engines on lowered octane ratings. Dr. Hughes explained that the combination worked only in clean, new engines, and was non-effective in dirty engines. He also pointed out that water destroys the effectiveness of the boron compounds and that water is present in gasoline.

Dr. Hughes is director of The Standard Oil Company (Ohio) research laboratories.

Pure Oil Announces Engineering Promotions

William D. Kinsell has been appointed manager of the Construction Engineering Department of The Pure Oil Company, and Daniel E. Sullivan, former director of engineering, has been named

DO BUBBLE TOWERS BOTTLENECK Your PLANT?

Skelly Oil Company, Leonard Refineries, Barnsdall Oil Company, Hope Natural Gas, and many others, have increased their tower capacities from 30% to 50% by replacing conventional bubble trays with

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Here's all you do to find the answer to your overloaded tower problem: Tell us the size of your existing tower, the vapor and liquid capacities you desire, and we'll tell you what you can obtain with

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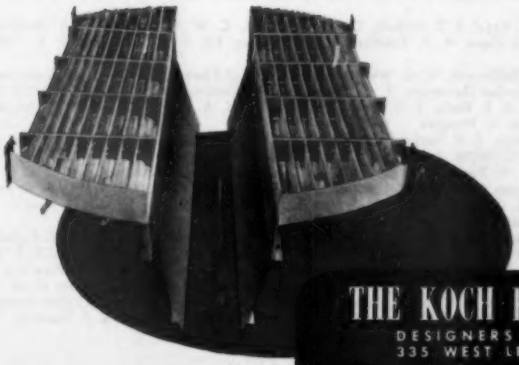

THE KOCH ENGINEERING COMPANY, INC.

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New York City	412 Peoples Gas Bldg.	Wright Bldg.	Paisley, Scotland

The MONTH . . .

engineering consultant, to serve all divisions of the company. C. A. Peterson will continue as chief engineer of Marketing Construction, with responsibility for all design and construction engineering covering projects in the marketing division.

Kinsell, a native of Columbus, Ohio, has been with the company for 26 years. Peterson comes from New Orleans and has been with Pure for 25 years. Sullivan has just completed 33 years with the company.

Technical Men's Meeting Spotlights Defense Needs

Nearly 250 key technical men of Standard Oil Company (Indiana) met at French Lick, Ind., last month to hear discussion of methods of supplying the critical petroleum products needed for the national defense and listen to 79 technical papers. This year's meeting of Indiana Standard with its subsidiaries marked the ninth Joint Technical Meeting. Emphasis was given discussions on high octane gasoline, jet fuels, heavy-duty motor oils, benzene and other chemicals from petroleum, and methods of increasing the supply of crude oil.

J. F. Vanecek discussed methods of solving aviation gasoline problems, and warned that making gasoline of Grade 115/145 instead of 100/130 will require expensive processing and some loss in national refinery capacity. H. R. Taliaferro said that partial relief might be obtained by specification changes in current high-output aircraft engines.

An estimate that 100 billion barrels of crude will be within reach within the next 50 years because of discovery of new methods for recovering oil from the ground was made by L. E. Elkins. The other side of the picture was presented by L. I. Smith and H. S. Seelig who reported progress on methods of making liquid fuels from natural gas and from oil shale.

Companies represented at the meeting were Standard Oil Company (Indiana), Pan American Petroleum and Transport Company, Pan-Am Southern Corporation, Utah Oil Refining Company, Stanolind Oil & Gas Company, and the Service Pipe Line Company. Consultants from various universities were also present.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.
(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1950:									
January 28	4,956	5,470	248,411	18,363	124,270	7,302	66,337	8,389	57,036
February 25	5,000	5,277	245,586	17,703	133,886	6,990	56,056	7,855	48,663
March 25	4,848	5,469	244,227	17,939	135,406	6,870	40,577	8,171	42,546
April 29	5,014	5,314	244,744	18,039	128,655	6,531	36,696	7,272	39,260
May 27	5,119	5,591	240,942	18,704	122,757	7,201	40,607	7,421	39,308
June 24	5,353	5,636	240,762	19,626	115,036	6,868	50,580	7,461	41,291
July 29	5,522	5,870	240,236	19,981	109,076	7,266	61,437	7,870	42,253
August 26	5,699	6,197	236,934	20,263	105,793	7,559	65,841	8,543	41,697
September 30	5,903	6,051	241,631	19,624	104,383	8,460	76,734	8,306	42,330
October 28	5,895	6,051	244,805	19,878	105,062	8,250	84,057	8,449	44,310
November 25	5,888	6,238	244,497	19,847	106,424	8,591	86,768	8,470	45,566
December 23	5,763	6,150	250,799	20,075	112,631	9,436	73,273	8,715	39,914
1951:									
January 27	6,066	6,483	244,230	21,106	126,261	9,954	58,997	9,905	40,378
February 24	5,934	6,524	237,304	20,815	136,870	10,545	48,764	9,471	38,995
March 31	6,041	6,381	235,956	20,398	142,186	9,365	43,170	9,147	37,282
April 28	6,154	6,236	242,479	19,876	137,474	8,061	43,850	8,747	36,080
May 26	6,163	6,430	246,400	21,102	130,819	8,580	51,244	9,045	37,265

Cummings to Command QM Petroleum Augmentation

Colonel Carl E. Cummings (Reserve), superintendent of Texaco's Beacon laboratories, was named commanding officer of the Army Quartermaster General's Petroleum Augmentation Unit, organized in November, 1950, as an integral part of the Organized Reserve Corps program. The unit is a nucleus

Indiana Standard Technical Staff in Annual Gathering

Photo taken of key technical men from the Standard Oil Company (Indiana) and its subsidiaries during ninth joint technical meeting in May at French Lick. All shown are from Indiana Standard except those marked with I (Indoil Chemical Company), SOG (Stanolind Oil and Gas Company), SPL (Service Pipe Line Company), PA (Pan American Petroleum & Transport Company), PAS (Pan-Am Southern Corporation), U (Utah Oil Refining Company), and C (Consultant).

Row 1 (Bottom)—J. O. Howe, Pike H. Sullivan, G. T. Wilson, R. E. Vogel, J. E. Seebold, C. L. Parris, PAS; C. W. Peters, PAS; G. E. Schmitkons, Robert E. Wilson, J. K. Roberts, R. C. Gunness, J. E. Kasch, PA; A. L. Conn, H. R. Taliaferro, O. W. Collier, PA; F. H. MacLaren, R. L. Yahnke, R. F. Gasvoda, and G. W. Ritter.

Row 2—Norman Sauter, W. H. Bahlke, J. W. Gaynor, J. B. Duckworth, W. G. Whitman, Department of Chemical Engineering, Massachusetts Institute of Technology; H. C. Brown, Department of Chemistry, Purdue University; J. C. Ducommun, F. Cushing Smith, R. T. Colquette, PAS; R. O. McKinley, H. M. Steininger, T. A. Abbott, M. T. Carpenter, A. B. Blake, R. V. Shankland, R. A. Steel, A. C. Hershey, J. H. Krause, J. W. Healy, Scott W. Walker, SOG; E. W. Thiele, H. B. Higgins, and M. C. Hopkins.

Row 3—R. N. Giles, J. H. Rushton, Illinois Institute of Technology; E. B. Tucker, T. H. Rogers, P. R. Schultz, SOG; G. W. Watts, C. F. Feuchter, PA; C. C. Campbell, K. L. Carter, P. J. Perille, E. L. d'Ouville, P. C. White, J. E. Kline, C. M. Loane, Hal M. Hart, Frank J. Smith, PA; Nathan Fragen, R. Mungen, SOG; Wm. Kaplan, PA; B. H. Shoemaker, J. N. Roper, J. F. Vanecek, W. B. Littreal, U; E. J. Luetzelschwab, and M. D. Gjerde.

Row 4—E. W. Adams, H. R. Garrison, PA; H. D. Radford, PA; Moses Gordon, A. L. Jackson, F. W. Scheineman, E. A. Metcalf, G. F. Ordeman, C. G. Kustner, D. B. Mapes, SOG; J. D. Eisler, SOG; H. J. Liehe, L. C. Brunstrum, W. F. Meehan, L. G. Lewis, M. H. Arreson, I; H. A. Parker, R. B. Jacobs, A. W. Neeley, U; F. R. Clarke, U; D. R. Isom, U; C. R. Harte, R. F. Marschner, and E. K. Brown.

Row 5—W. R. Ramalia, PAS; R. J. Hengstebeck, R. W. Watson, L. T. Wright, A. H. Fox, C. N. Sechrist, PA; F. L. Anderson, PA; R. J. Hafsten, L. E. Schaffer, E. D. McKeague, R. C. Mallatt, W. M. Patterson, PA; W. R. Hertwig, G. T. Moore, E. E. Hurley, SPL; E. A. Slade, SPL; R. E. Karll, H. L. Hilleary, H. R. Boehmer, C. C. Buchler, W. M. Dudley, A. B. Brown, H. V. Knight, W. B. Plummer, I; L. E. Elkins, SOG, and A. H. Newberg, SPL.

Row 6 (Top)—R. H. Price, PA; L. W. Mixon, Curtis Smith, Howard R. Peterson, I; R. L. Baldner, SOG; E. L. Gordy, N. E. Lemmon, H. W. Skov, E. H. Harclerode, G. M. Webb, W. L. Rittschof, E. G. Spittswood, PA; P. L. Brandt, PA; R. J. Lee, PA; E. F. Smith, L. L. Smith, SOG; Donald B. Edwards, SOG; J. A. Ridgway, PA; L. T. Gerget, PA; G. W. Meyer, PA; P. F. Hawley, SOG; C. C. Miller, B. M. Cooke, and D. S. Warning.

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From Abadan to Llandarcy...with AIOC!

In its twenty year association with the Anglo-Iranian Oil Co., Ltd., Kellogg has undertaken the design and construction of more than forty process units.

From the Persian Gulf to Wales and Scotland...from Palestine to France and England, these have run the process gamut from simple pipe stills to the most advanced Fluid catalytic crackers. The list embraces alkylation and isomerization units, phosphoric acid treaters, thermal crackers and reformers . . . as well as many primary fractionation units.

Currently, Kellogg is engaged in the construction of three Fluid catalytic cracking units for AIOC, one each in Grangemouth (Scotland), Kent (England), and Llandarcy (Wales).

THE M. W. KELLOGG COMPANY

A SUBSIDIARY OF PULLMAN INCORPORATED

for fifty years an integral part of processing history

NEW YORK JERSEY CITY LOS ANGELES TULSA HOUSTON TORONTO LONDON PARIS

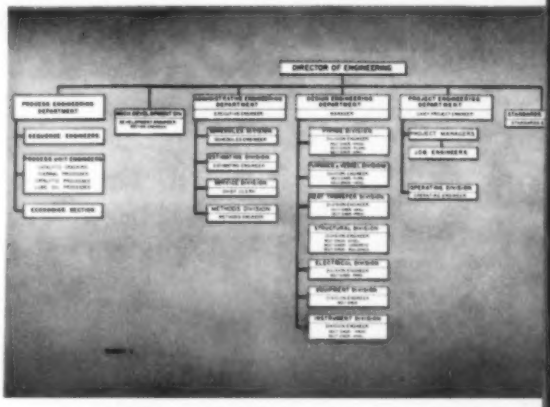
Portrait at

This year is Kellogg's fiftieth of service to industry. At this time naturally, as a group of men—known collectively to the modern business world as The M. W. Kellogg Company—we can think back nostalgically. We can remember the chimney stacks

"Details by the Million"

Previous camera "portraits" of M. W. Kellogg today, appearing in this publication, have described the broad outline of the development phases of the Kellogg operation and have pointed out how the results of these diversified efforts are channeled to the industry through Process Engineering.

This month, some aspects of Kellogg's Design Engineering Department are examined to illustrate how "details by the million" are marshalled into final working plans.



1. *TO HANDLE THE DETAILED* engineering of one refinery unit requires a diverse staff of engineers and a corps of draftsmen. To handle *20 or 30 such jobs simultaneously* calls for a veritable "army" of technical personnel. This chart shows how the company's Engineering Departments are organized. The focal point of administrative and quality control is the Director of Engineering.

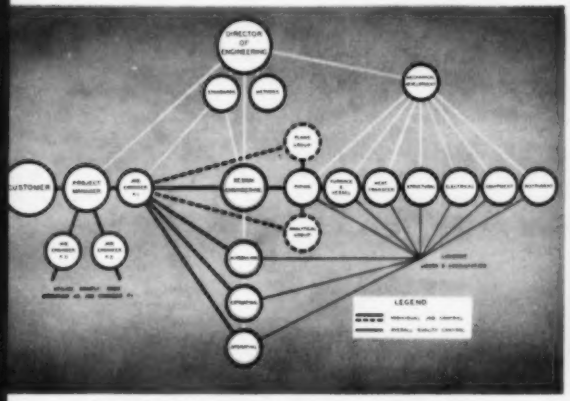
4. *WITH THE CUSTOMER'S APPROVAL* of plot plans, piping layouts, elevations, utility plans and materials specification in hand, detailed engineering of all phases of a unit can proceed simultaneously. And it does at Kellogg because of the vast technical man-power pool. Above is pictured the north side of one entire floor of the company's offices devoted to *piping* engineering alone.

5. *THIS IS THE EAST SIDE OF* the same *piping engineering* floor . . .

Fifty... no 5

KELLOGG
1901-1951
50th Anniversary

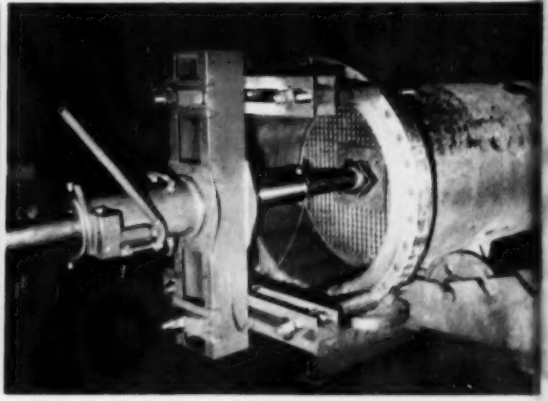
we built in 1901 . . . the first crude vessels for oil refiners in the 'teens . . . our first combination unit. The forty-odd Fluid cat crackers built in these years. But, after all, The M. W. Kellogg Company is only a factor as it is able to serve industry today. For that reason, we are presenting this series of monthly camera studies which document our belief that a truly integrated organization can better serve industry to achieve greater earning power. This is No. 5 in the series.



2. *SUCH VERTICAL CONTROL* insures top technical performance within the various technical specialties—but individual job performance and delivery require a different type of control. The above diagram indicates how horizontal control of individual jobs is achieved—bringing to each job the combined facilities of the entire organization. The apex of this control is the *Project Manager* of each individual job.

3. *FIRST STEP* in every project is its assignment to a Project Manager, who assumes overall responsibility. After receiving process data, the Project Manager, assisted by a *Job Engineer*, establishes specifications and then turns the project over to the *Plans* (pictured) and *Analytical Groups*. These latter establish within narrow limits all major engineering details of the proposed plant prior to the start of any detailed engineering.

6. . . . *AND HERE IS THE SOUTH SIDE.* All of these trained men specialize in just one phase of refinery engineering . . . *piping*. In total, mechanical design engineering personnel alone occupy some 30,000 square feet of space.



7. *IN THE ENGINEERING DEPARTMENT*, there is a special group of engineers which does nothing else but concentrate on mechanical development problems posed by the various specialized engineering sections. New types of valves, completely new hydraulic exchanger-bundle pullers (illustrated), new types of piping supports, are but a few of the improvements that have come from this group.

NEXT MONTH

. . . in the sixth in this series of camera studies of M. W. Kellogg today . . . you will glimpse a few of the many supporting groups and special devices that Kellogg uses to get the most out of its Design Engineering talent.

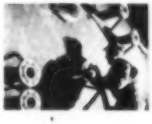
The proper bevel for the perfect weld!

M. W. KELLOGG

There's no particular trick to cutting a nozzle hole in a vessel when its location has been clearly indicated by a qualified layout man. But there is quite a trick to cutting these holes with the proper bevel to produce a perfect welded joint when the nozzle is attached. Perfection in such details is why "Kellogg-fabrication" is specified for the industry's more important vessel orders.

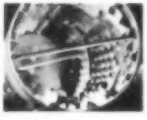
Pressure Vessels
Vacuum Vessels
Fractionating Columns
Drums and Shells
Heat Exchangers
Process Piping
Hi-pressure—Hi-temp Power Piping
Bends and Headers
Giant One-Piece Bends
Forged and Welded Fittings
Radial Brick Chimneys

Continuing Study of behavior of metals under stress at high temperatures has produced valuable design data.

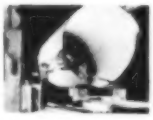


Shop Layout Craftsmen are fully experienced in vessel fabrication from nozzle positioning to "knockdown" fabrication for field assembly.

Extensive Facilities from forming of plate to final machining of precision surfaces permit complete fabrication under the same roof.



Special Welding Techniques and stress relieving methods assure equipment performance even under severest operating conditions.



Rigid Quality Control, devised by specialists, including chemical and micro analyses as well as mechanical and non-destructive testing

NEWS FOR OPERATORS IN WESTERN CANADA!

The Canadian Kellogg Company Ltd. has established complete shop facilities for the fabrication of all types of piping at **EDMONTON**, Alberta. Inquire directly or through any Kellogg or Canadian Kellogg office.

The M. W. Kellogg Company *(A Subsidiary of Pullman Incorporated)* **New York, Jersey City, Los Angeles, Tulsa, Houston, Toronto, London, Paris**

The MONTH...

for rapid expansion of the Army's petroleum organization in the event of an emergency, and includes 17 other reserve officers.

CCC Recognizes Hanker

Catalytic Construction Company, Philadelphia, has named Fred C. Hanker, Jr., who has been associated with the petroleum industry since 1935, assistant to the president. Prior to his association with Catalytic, Hanker was a process engineer with Standard Oil Development Company and during the early 1940's was active in design and installation of aviation gasoline facilities for Standard Oil Company (New Jersey). From 1944 to 1948 he was with The Carter Oil Company as assistant to the vice president of the manufacturing department and actively participated in the development of Carter's Billings, Mont., refinery.

Hanker

Oil Conditions Reflected In Nation's Life—Porter

Oil operations are spread across both hemispheres and among many nations that what happens in one part of the oil world must have its effect in some measure on every other part, Frank M. Porter told the Third World Petroleum Congress assembled at The Hague early this month.

"Today," he said, "we cannot think of the industry in our own particular country as a unique, separate entity, it is definitely an interdependent segment of a world-wide industrial enterprise dedicated to a never-ceasing effort to better man's welfare and lighten his burdens. That is why the World Petroleum Congress is of untold value."

He pointed to the exchange of knowledge which has characterized the present and previous Congresses as an example pointing the road to world peace, the acceptance of a common purpose to serve people and not ends.

"There are no longer any geographic boundaries to the activities of the petroleum industry," said Porter. "There can no longer be any geographic boundaries to our thinking and our action in regard to these activities, nor any boundaries in our technology and research activities."

Porter added that the tremendous importance of petroleum to national life and international trade have focused the attention of all nations on the industry.

Socony Expands to Meet Bead Catalyst Demand

Bead catalysts used in Socony-Vacuum's Thermofor catalytic cracking (TCC) process met with such increased demand that the company enlarged its bead plant at the Paulsboro, N. J., refinery. The original bead catalyst plant was erected in 1943 and expansion involved additions to all elements except

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PRECISION MOLDED
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3. Controlled Uniformity
4. Attractive Smooth Finish
5. Greater "Ductile Strength"
6. Cleaner
7. More Durable
8. Easier To Apply
9. Precision Pipe Fit
10. Simplified Thickness Standards
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●Putting Visco dehydrating and desalting chemicals to work for you is an absolute guarantee (in writing, if you wish) of *consistently uniform* emulsion-breaking efficiency. Every one of the big blue Visco barrels contains 55 gallons of *working* emulsion-breaker... to give you minimum cost per barrel of dry oil. Call Houston, CAPITOL 7300, collect, for prompt action or more details on Visco chemicals and field service.

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The MONTH...

the forming towers and dryers.

A 70-foot extension provides 3000 more square feet of floor space. In addition, four wash tanks of approximately 35,000 gallons each capacity were installed, together with a new tempering kiln capable of treating 75 tons a day.

$10 Billion Estimated Cost of Recent Expansion

More than $10 billion dollars has been spent in expanding the oil industry in the last five years, estimated Thomas W. Phelps, official of Socony-Vacuum Oil Company, and an additional $15 billion will be spent in the next nine years to keep pace with anticipated growth in demand.

Phelps based his estimates on rough figures that indicated it costs $5000 for each barrel-a-day added to the present capacity, and of this amount between $2.3 to $2.6 thousand is spent to develop each barrel of additional capacity of crude oil, he said.

Daily oil production in the U. S. is expected to average 8,650,000 barrels by 1960, Phelps stated, to compare with an estimated daily capacity of 7 million for 1951.

Ohio Elects Redpath VP, Announces Expansion Plans

E. B. Redpath, secretary of the Ohio Oil Company since 1928, last month was elected executive vice president. H. H. West, formerly assistant to president J. C. Donnell II, was elected secretary to succeed Redpath.

Stockholders were told that Ohio Oil's refinery at Robinson, Ill., is scheduled for "a number of new facilities."

Abboud Joins Toledo Firm

Alfred Abboud, associated with the Project Engineering division of E. B. Badger & Sons Company for the past ten years, has been appointed manager of the Chemical and Refinery division of Kaighin & Hughes, Inc., Toledo engineering firm.

Abboud

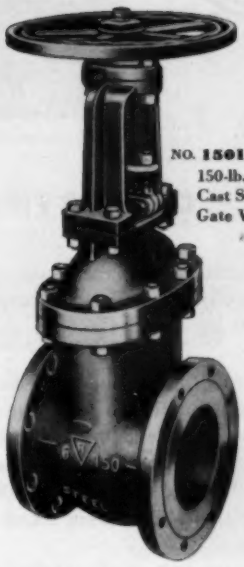
Abboud, a lifelong resident of Boston and a graduate of Massachusetts Institute of Technology, will move to Toledo.

Kaighin & Hughes contemplate greatly expanding activities to take care of a much broader field of planning and construction, according to officials.

Gulf Adds $1 Million Laboratory at Harmarville

Construction on a new chemical research laboratory at Gulf Oil Corporation's research center started recently in Harmarville, Pa., is scheduled for completion in about 12 months. The $1.1 million project will consist of a three-story building containing 33 laboratory rooms, 25 offices, etc. The new 33,000 square feet of gross floor space will

R·P&C VALVES



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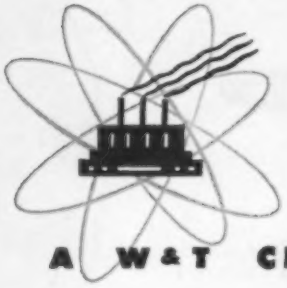
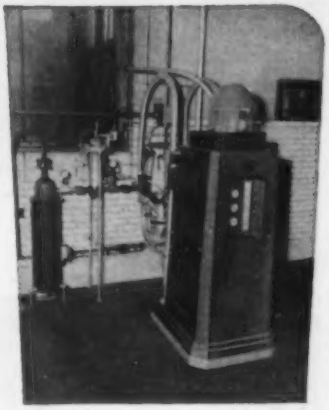
READING-PRATT & CADY VALVES

SAXTON'S SECRET WEAPON . . .





W&T Chlorinator Installation at Saxton Station

A W&T CHLORINATOR

In winning their battle against condenser slime at the Saxton Generating Station, Pennsylvania Electric Company, in their company publication, called the Wallace & Tiernan Chlorinator their "Secret Weapon."

Here's what happened before chlorine was tried. Experience showed even a small accumulation of slime caused a one inch loss in condenser vacuum — equivalent to a five to ten per cent reduction in plant efficiency. Frequent mechanical cleaning — expensive and disagreeable — still left a thin layer of slime. Cleaning compounds involving acids and alkalis were found an unsatisfactory answer to the problem.

Then Chlorine was tried! Preliminary tests indicated that coal consumption could be decreased by about $75 per day. *But,* feeding chlorine without special equipment proved both expensive and dangerous. A slight variation in feed rates resulted either in insufficient treatment or excessive chemical costs.

As a result of these tests, a Wallace & Tiernan Automatic Chlorinator was installed at Saxton in May 1949. This precision chlorinator made possible reduced coal consumption and virtual elimination of mechanical tube cleaning — the reasons why a W&T Chlorinator is Saxton's "Secret Weapon."

Hundreds of power plants have had benefits similar to those at the Saxton Station. Your W&T Engineer is prepared to help solve your slime problems — why not write for more information today — no obligation, of course.

CD-36

WALLACE & TIERNAN PRODUCTS, INC.

CHLORINE AND CHEMICAL CONTROL EQUIPMENT

Belleville 9, New Jersey • Represented in Principal Cities

The MONTH . . .

house the product development, analysis, and organic synthesis sections.

Safety features include showers in the corridors every four doors, and interconnecting doors in all laboratories to provide two exits for each unit. Chemical fumes will be carried off by exhaust fans through hoods in each laboratory.

A glass washing room for centralized cleaning of used chemical vessels will be provided.

PAD Lists Conditions of Meeting Petroleum Demand

A probable increased demand of ten percent for petroleum products in 1951, with a further five percent rise early in 1952, can be met under "certain conditions" according to PAD. Conditions are that domestic crude production must be maintained at an average of 6,065,000 barrels a day, a 12.3 percent increase over the 1950 rate; imports must average 950,000 barrels a day, or more than 100,000 daily barrels over the 1950 average; refinery runs must average 6,425,000 barrels a day, rising to a peak of 6,605,000 in the first quarter of 1952; and a determined effort must be made to fill all available storage this summer, including refinery tanks, primary and secondary terminals and consumer tanks.

Cecil L. Burrill, director of PAD's Program Division, estimated U. S. refining capacity to be 6,900,000 barrels a day at the end of 1950, and guessed that 1951 capacity would reach roughly 7,200,000 barrels.

Abadan Shutdown a Threat To Refining Production

At month's end Iran had told representatives of Anglo-American Oil Company that it would take over the company "in progressive stages," that an Iranian managing board would assume control and that the British technical gradually would be replaced by Iranians.

Great Britain had asked the International Court at The Hague to intervene but Iran claimed that it is a matter with which the tribunal should not be concerned. Conditions in Iran were described as exceedingly tense.

Refinery production, should the 550,000-barrel-daily plant at Abadan be closed, is the chief concern. Crude production could be stepped up in other Middle Eastern fields, it was pointed out, but a shutdown at Abadan would put a real strain on refineries of the United States which are already up to 93 percent of their total 7-million-barrel-daily capacity. Additional demands on domestic refineries would call for maximum runs, leaving no shutdown time for repairs, etc.

Officials pointed out that new refining capacity, now under construction, would not, generally speaking, be ready for almost a year.

API Sets 1952 Dates

The 1952 annual meeting of the American Petroleum Institute will be held in Chicago, November 10-13, inclusive.

WPRA Regional Meetings

Three additional regional meetings have been scheduled by the WPRA according to J. C. Day, WPRA secretary,

Now... NUMBER OF TANKS AND DISTANCE Unlimited

ACCURATE *Remote* LIQUID LEVEL GAUGING

Fig. No. 850R Electronic Gauger Transmitter installed with "VAREC" Fig. No. 253 Automatic Tank Gauge.

"VAREC" Field Telephone Link Transmitter.

Fig. No. 801 "VAREC" Electronic Gauge Receiver.

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Now, with "Varec's" unique new Field Telephone Link Transmitter, (when used in conjunction with its Electronic Gauger Receiver and Electronic Gauger Transmitter) distance factors are literally unlimited, as are the number of tanks possible to gauge from a single remote point.

At the turn of a dial switch, accurate, **REMOTE** liquid level gauging in oil refineries, chemical plants, pipe line pump stations and storage terminals is an important reality.

Utilization of existing telephone or power lines minimize installation and wiring costs, in addition to material savings realized in time, labor and accurate gauging with a "Varec" Electronic Gauger installation.

Now it is possible for only one gauger or operator to obtain accurate (within ⅛") continuous gauge readings from any one or a series of tanks simultaneously. The operator needs no special electronic knowledge to maintain or service the "Varec" unit as all parts are of standard plug-in design.

A complete extra service kit is included to assure continuous, dependable operation. WESTON Meter equipped. Low voltage, low current transmission only 0.001 volts D.C. at explosion-proof tank transmitter. Designed to operate from 110-115 volt, 50-60 cycle A.C. or 220 A.C. power at receiver.

There's a "Varec" Electronic **REMOTE** Liquid Level Gauging unit to meet your requirements. Where close control of blending operations is desired, automatic high and low valve, pump and alarm control is available. Write for our recommendations on your gauging problems today.

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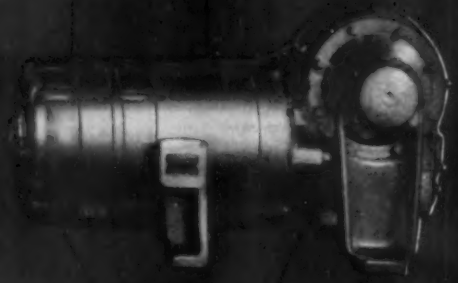
P-18



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Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor driven products . . . improve the economy and productivity of your plant equipment.

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The MONTH...

as follows: July 19-20, Broadview Hotel, Wichita; August 17, Leonard Refineries auditorium, Alma, Mich.; September 20-21, Hotel Henning, Casper, Wyo. The Wichita and Casper meetings will be joint technical-industrial relations meetings. The Alma meeting is limited to technical matters.

Rig to Test High-Speed Gears Developed by Texaco

A test rig based on a machine originally designed by Pratt & Whitney Aircraft for bench testing gears and lubricants has been converted by the engineering department of The Texas Company's Beacon, N. Y., laboratories into an improved method for testing the critical lubrication requirements of high-speed precision gears. The "new" rig incorporates design features which extend the speed and load range to permit speeds up to 16,000 rpm. under loads which are the equivalent of those loads present in operations where small gears transfer 5000 hp.

With the modification, Texaco engineers are able to accumulate significant data in a new class of lubricating problems which have arisen with the rapidly growing use of gas turbines in aircraft and railroad engines. Research on the behavior of lubricants under operating conditions arising from the combination of higher speeds and higher loads can now be studied, enabling the company to develop lubricants which will promote more efficient operation of high-speed high-load gears.

Aircraft turbo-prop engines require that gears must start at 65° F. below zero and run at 200 to 300° F. A test run of the high-speed precision gears extends from initial operation until a failure of the gear surfaces appears. Constant speed with progressive loading is maintained during the run.

Preliminary studies for developing the rig were started at the Beacon Laboratories about five years ago.

Casey New Pan-Am Director

Sam H. Casey, assistant to the executive vice president of Pan-Am Southern Corporation, has been elected a member of the board of directors. Casey, a graduate of the University of Illinois and Milliken University, joined Pan-Am in 1948 as manager of the Crude Oil Purchasing department. He had previously been associated with Sohio Petroleum Company as manager of the Industrial Relations and Personnel department.

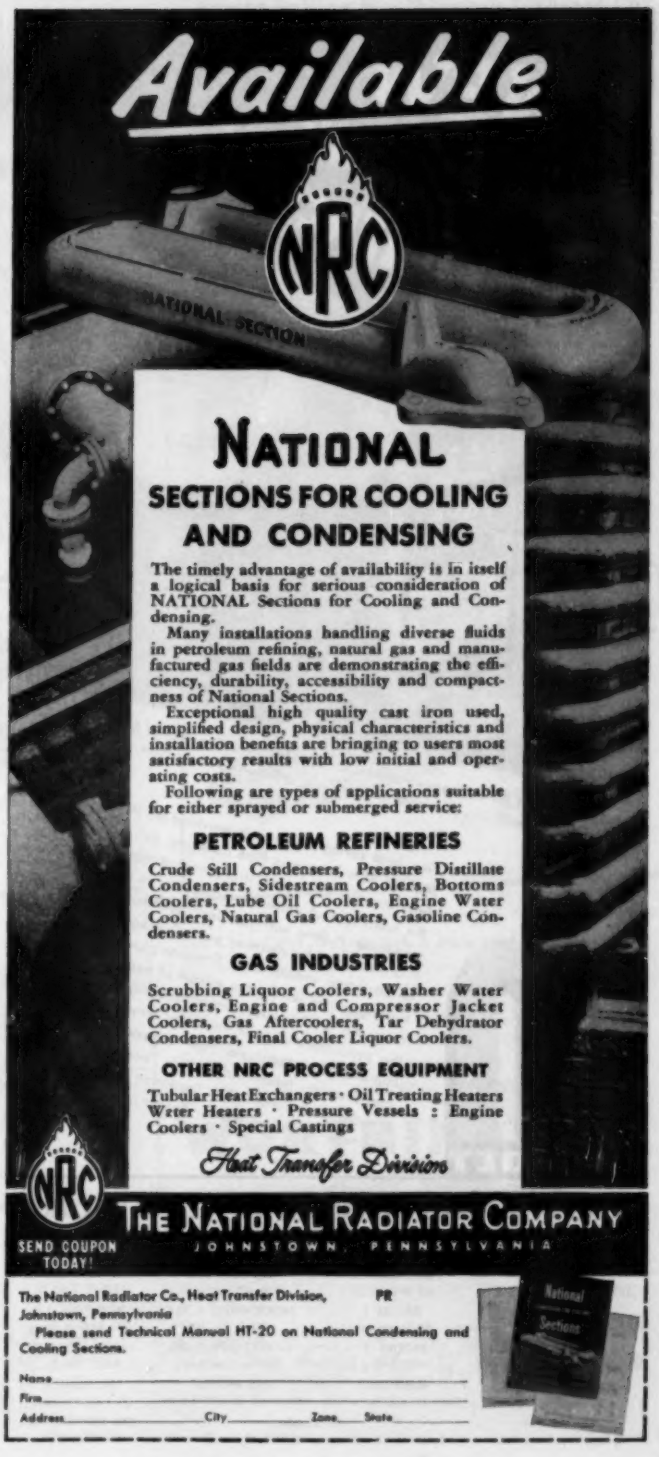
Lawrence H. Norman was appointed to replace Casey as assistant to Aycock.

Fuel Oil Publicity Unit

For the first time in its history, the fuel oil industry is to have a centrally-directed publicity campaign which has already been set in motion by the Fuel Oil Foundation. In addition to the publicity program, the Fuel Oil Foundation, 122 East 42nd Street, New York, will continue to provide advertising aids, promotional literature, etc.

Dodd Succeeds Lonsdale

William Lonsdale, vice president in charge of manufacturing, retired last month and was succeeded by Gerald D.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The timely advantage of availability is in itself a logical basis for serious consideration of NATIONAL Sections for Cooling and Condensing.
Many installations handling diverse fluids in petroleum refining, natural gas and manufactured gas fields are demonstrating the efficiency, durability, accessibility and compactness of National Sections.
Exceptional high quality cast iron used, simplified design, physical characteristics and installation benefits are bringing to users most satisfactory results with low initial and operating costs.
Following are types of applications suitable for either sprayed or submerged service:
PETROLEUM REFINERIES
Crude Still Condensers, Pressure Distillate Condensers, Sidestream Coolers, Bottoms Coolers, Lube Oil Coolers, Engine Water Coolers, Natural Gas Coolers, Gasoline Condensers.
GAS INDUSTRIES
Scrubbing Liquor Coolers, Washer Water Coolers, Engine and Compressor Jacket Coolers, Gas Aftercoolers, Tar Dehydrator Condensers, Final Cooler Liquor Coolers.
OTHER NRC PROCESS EQUIPMENT
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The MONTH . . .

Dodd, formerly assistant to the president of Foster Wheeler Corporation. Dodd's new responsibility will be direction of manufacturing at the company's Carteret, N. J., and Dansville, N. Y., plants. Dodd joined the company in 1929 and became assistant to the president in 1950.

Awarded for Over Million Manhours Without Injury

For a safety record that boasted an entire calendar year without a lost time injury, the employes of the Sweeney, Texas, refinery of Phillips Oil Company were awarded a National Safety Council plaque and an American Petroleum Institute certificate of safety for outstanding achievements during 1950. These awards of honor for distinguished service to safety are presented annually by the NSC to all branches of the petroleum industry.

Although ten other refineries with a comparable number of employes also had perfect safety records for a period numbering one million manhours, the Phillips plant accounted for more than one million manhours without a disabling injury.

C. C. Tate, manager of Phillips refining department, also presented the employes with individual awards from the company in recognition of their safety records.

Dr. Rossini Is Honored

Dr. Frederick D. Rossini, professor and head of the department of chemistry at Carnegie Institute of Technology, has been elected to the National Academy of Sciences. Twenty-nine American scientists were recently elected, bringing the national membership to 481. In addition to his other assignments Dr. Rossini is also director of the Petroleum Research Laboratory which is engaged in a study of distillation of crude oil and its various fractions.

W. L. Templin Promoted

W. L. Templin, division wage and salary analyst for Stanolind Oil and Gas Company since 1948, has been promoted to division industrial relations supervisor. He joined Stanolind in April, 1940, as a roustabout in the Lucien area in central Oklahoma. He rejoined the company after Air Force service and in 1946 was sent to Oklahoma City.

Colonel Gidney Retires

Colonel Herbert A. Gidney who has been associated with Gulf Oil Corporation for 31 years retired late last month. He had been a member of the board, executive vice president, a member of the executive committee, finance committee and many other important management and employe benefits groups.

Griswold Joins Allied Chem

John Griswold resigned recently as professor of chemical engineering at Illinois Institute of Technology to become full-time consultant to General Chemical Division, Allied Chemical & Dye Corporation. Griswold will be located in New York.

5 Ways

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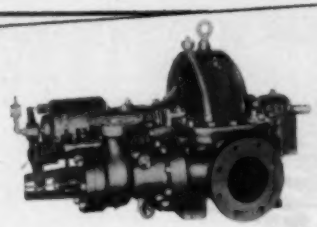
Worthington Turbines are built in all sizes and types — including straight condensing, straight non-condensing, extraction, mixed pressure extraction, low pressure and high back pressure — to meet the widest range of requirements. Steam or gas driven, for mechanical or generator drive, all are available with governors for constant or variable speeds. If desired, control devices can be incorporated in the governor.



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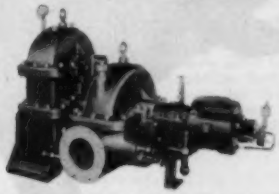
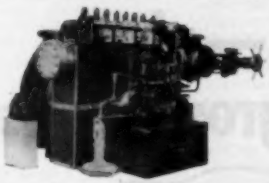


Single Stage With Integral Reduction Gear. Sizes up to 200 hp. A compact, sturdy, dependable unit with economical turbine operation. Especially suited for driving slow or moderate speed auxiliaries at low steam consumption.



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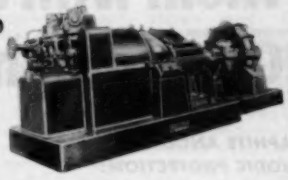
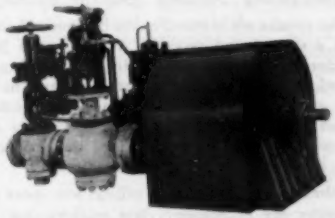


Multi-Stage With Separate Gear. Like all Worthington Multi-Stage Turbines, these are available in all types and are readily adaptable to special applications. Recommended for driving low speed equipment such as condenser circulating pumps, water supply pumps, etc.



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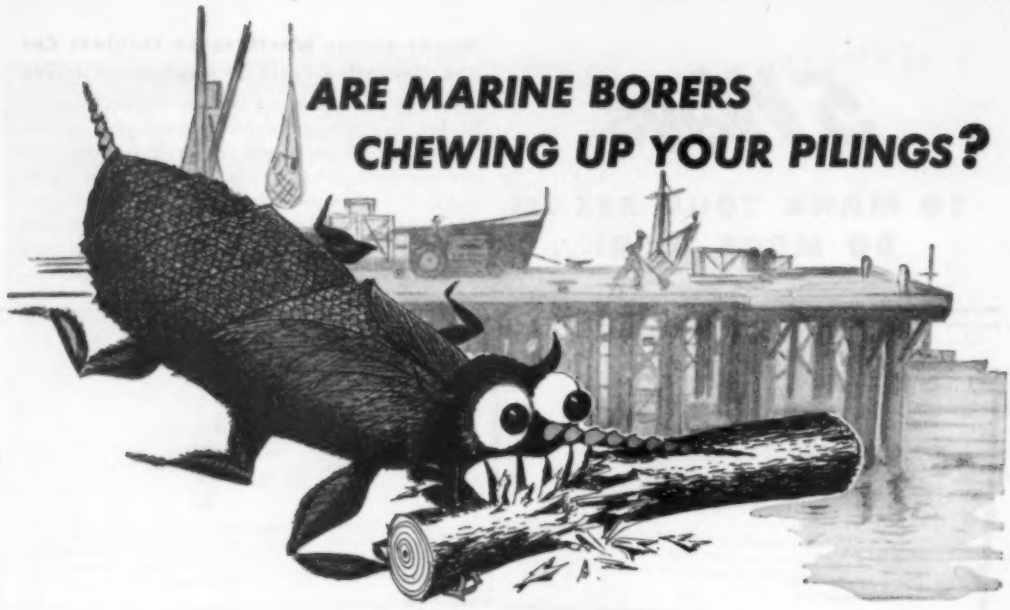

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SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

The price of gasoline, excluding taxes, is about the same today as it was 25 years ago; in addition, quality has been improved so much that two gallons of 1950 gasoline do the work required by three gallons in 1925.

Chemical Composition and Reactions

Ethanol from Methanol. IRVING WENDER, R. A. FRIEDEL AND MILTON ORCHIN. *Science*, **113** (1951), pp. 206-7.

Alcohol is treated with synthesis gas composed of carbon monoxide and hydrogen at 180° to 185° C. in the presence of a cobalt catalyst. The reactivity of the alcohols is in the order: tertiary, secondary, primary. The simplest alcohol, methanol is different from the other alcohols in that it reacts with synthesis gas more rapidly than secondary alcohols. The main product of the reaction is ethyl alcohol. This posseses the possibility of an interesting synthesis of ethyl alcohol which may be important commercially. The reaction products contain almost no higher alcohols. The yield of ethanol from methanol can probably be increased by increasing the ratio of hydrogen to carbon monoxide in the synthesis gas. Any salt of cobalt that yields the carbonyl under the conditions of the reaction will be an effective catalyst.

Trifluoropropyne. ALBERT L. HENNE AND MAXWELL NAGER. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 1042-3.

Three syntheses for trifluoropropyne are given. One of them is preferable, in that it gives a yield of 90 percent or better for each step, and an over-all yield of 73 percent. The boiling point of trifluoropropyne is —46 ± 2° C., latent heat of vaporization 4640 ± 200 calories, from which it may be judged that there is no molecular association. This it attributed to the electro-negative induction of the —CF_3 group which depletes the triple bond electronically. An infrared spectrum of the compound is given and discussed.

Alkenylation of Aromatics with Butadiene: A Synthesis of 1-Phenyl-2-Butene WAYNE PROELL. *J. Org. Chem.*, **16** (1951), pp. 178-84.

Alkenylation of aromatic hydrocarbons is promoted by alkanesulfonic acids. Butadiene reacts with aromatic hydrocarbons at temperatures up to 150° C. in the presence of 5 percent or more of alkanesulfonic acid as a catalyst. In the temperature range of 0-40° the products are butenyl and polybutenyl compounds. Above 40° C. the butenyl groups react further and the product includes diarylbutanes, arylbutenes, and more complex products. The reaction shows promise of being a general method for preparing arylalkenes. It was therefore studied in particular with respect to phenylbutene. The reaction of butadiene and benzene yields 1-phenyl-2-butene. With *p*-xylene, the product is apparently pure monobutenyl-*p*-xylene. Phenol, naphthalene, and methylnaphthalene also give butenyl derivatives. The reaction is most advantageously conducted in the temperature range 10-30° C.

Rearrangements Involving 1-Pentyne, 2-Pentyne and 1,2-Pentadiene. THOMAS L. JACOBS, RICHARD AKAWIE AND ROBERT G. COOPER. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 1273-6.

In order to study the rearrangements of the alkynes, a system was sought of sufficient simplicity for analysis of the components. Such a system is the series 1-pentyne, 1,2-pentadiene, 2-pentyne. Compounds are readily prepared, boil at convenient different temperatures, and have characteristically different infrared spectra. It was found that the rearrangement from 1-pentyne or 2-pentyne in alcoholic potassium hydroxide at 175° C. gave an equilibrium mixture containing 1.3 percent 1-pentyne, 3.5 percent 1,2-pentadiene and 95.2 percent 2-pentyne. 1,3-pentadiene sometimes polymerized too rapidly, but in one instance it gave the equilibrium mixture. 1,3-Pentadiene was not formed in the reaction. It was concluded that the rearrangement cannot involve addition and elimination of alcohol because it takes place in the presence of potassium hydroxide and in the absence of alcohol.

Alkylnaphthalenes. Part VI. 1:3-Dimethylnaphthalene. R. F. EVANS AND J. C. SMITH. *Jour. Inst. Pet.*, **37** (1951), pp. 80-90.

The synthesis used started with highly purified *m*-xylene and built on the second ring by the succinic anhydride method. Intermediate compounds were all carefully purified, and the final product was subjected to a series of purifications by distillation and low-temperature crystallization. The physical constants were determined after each procedure. In the synthesis of 1:3-dimethylnaphthalene, a crystalline sharp-melting solid was obtained at every stage: The overall yield from *m*-xylene was 52 percent. A bibliography of 25 references is included.

Rearrangement in the Reaction of 2,3,4-Trimethyl-3-pentanol with Hydrochloric Acid; Chlorination of 2,3,4-Trimethylpentane. HERBERT C. BROWN AND ROSLYN SILBER FLETCHER. *Jour. Am. Chem. Soc.*, **73** (1950), pp. 1317-20.

Hydrochloric acid reacts at room temperature with 2,3,4-trimethyl 3-pentanol to give a product, presumably 3-chloro-2,3,4-trimethylpentane. Hydrolysis of the product yields two components, one 22.9 percent of the reaction mixture, and the other 77.1 percent. The photochemical chlorination of 2,3,4-trimethylpentane at 25° yields a product which also comprises two isomeric tertiary chlorides. In this case the alpha component is 33.1 percent and the beta component 66.9 percent. The alpha component is 3-chloro-2,3,4-trimethylpentane; the beta component, 2-chloro-2,3,4-trimethylpentane. The ratio of primary to tertiary substitution in the hydrocarbon is 1:3.7.

These abstracts from the current literature of science and technology (not including trade journals easily available) were prepared by Drs. Leslie and Coats of The Leslie Laboratories, Traver Road, Ann Arbor, Mich., which will supply, at cost, photostatic copies of original articles. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also may be had by arrangement with the laboratories.

Manufacture: Processes and Plant

Petroleum Chemistry. Once a Quack Medicine, Petroleum Is Now the Mainstay of Giant Enterprises. G. EGLOFF AND M. L. ALEXANDER. *Ind. Eng. Chem.*, **43** (1951), pp. 809-19.

The history of the petroleum industry is traced from the early days of petroleum in Venango County, Pa., to the present time. Sections cover the periods from 1855 to 1900, and then by decades to the present. Development of cracking processes is traced, the founding of the Petroleum Division of the American Chemical Society is described, and the significance of the early programs, as well as special wartime developments are covered. The growth of chemicals from petroleum is traced. A bibliography of 25 historical references is included.

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Science and Technology

ing Vapours. Ju Chin Chu, M. Dmytryszyn, W. Tichy, K. C. Kubik and O. L. Smith. *Journal of Applied Chem.*, **1** (1951), pp. 73-80.

It has been demonstrated theoretically that the heat-transfer coefficient of a condensing vapour is a function of the rate of heat flow only. In the experimental work the rate of heat flow was varied by changing the flow of cooling water inside the condensing tube. The over-all temperature differences was varied by changing the pressure in the vapour space. By a proper combination of conditions the heat-transfer coefficients at constant rate of heat-transfer could be determined. The heat-transfer coefficients for trichloroethylene, bromobenzene, nitromethane and *n*-hexyl alcohol were determined. The heat-transfer coefficients predicted from Nusselt's equation agreed with those determined experimentally for trichloroethylene and bromobenzene, but not with those determined for nitromethane or *n*-hexyl alcohol.

True Temperature Difference in Split Flow. Donald Q. Kern and C. LeRoy Carpenter. *Chem. Eng. Progress*, **47** (1951), pp. 211-14.

Split flow is commonly used to attain low pressure drops in commercial heat-transfer equipment. The authors derive an equation for the true temperature difference in split-flow exchangers. It is shown that the equation of Underwood, which was derived for a 1-2 parallel-counterflow exchanger, is a special case of the more general split-flow equation.

Film Resistances in Rectification. K. S. Chari and J. Anderson Storrow. *Jour. of Applied Chem.*, **1** (1951), pp. 45-67.

Present knowledge of rectification of binary mixtures is largely concerned either with the ability to separate certain mixtures or with empirical methods of evaluating column performance in terms of accepted units of comparison. Few investigations attempting to explain the mechanism of the fractionation process have been reported. The authors present an analysis of rectification in a wetted-wall column in terms of postulated equations for film values of the height of a transfer unit. Discrepancies found in some of the correlations are no greater than are to be expected from the present lack of knowledge of the physical characteristics of the binary solutions, particularly as regards the diffusion coefficient in the liquid phase. A bibliography of 48 references is included.

Design of Packed Distillation Columns. III. Rectification Film Resistances in a Packed Column. C. H. G. Hands and F. R. Whitt. *Jour. of Applied Chem.*, **1** (1951), pp. 67-73.

Knowledge of the relative resistances of the liquid and vapor films in a distillation system is as important as it is in absorption systems. Little work has been published on the subject. Data are presented that lead to the conclusion that the liquid-film resistance is controlling in the rectification of a binary system in a packed column. Other workers have reached this same conclusion.

Design of Packed Distillation Columns. IV. An Empirical Method for the

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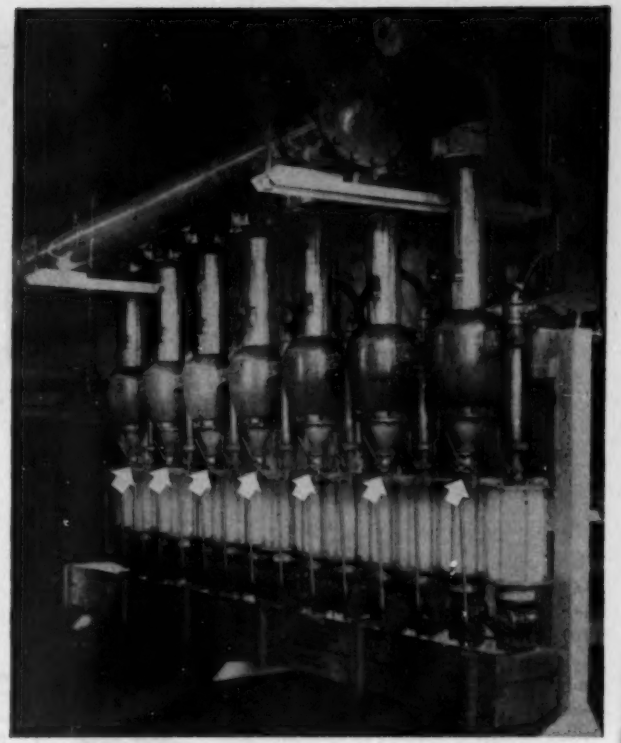

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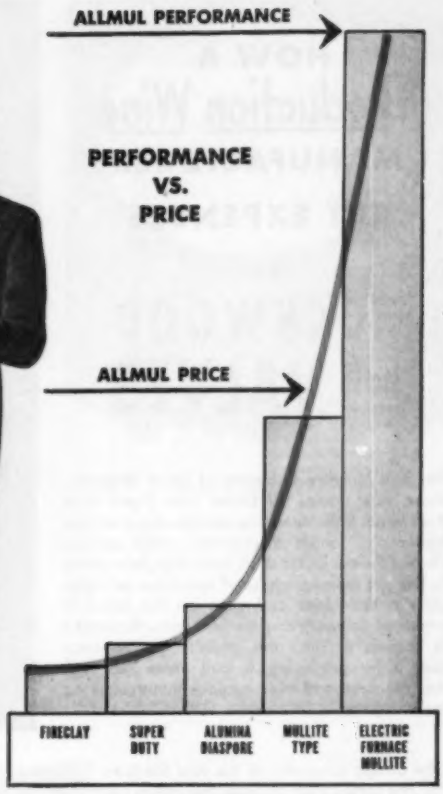

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Estimation of Column Height Using the H.E.T.P. Concept. C. H. G. HANDS AND F. R. WHITT. *Jour. of Applied Chem.*, **1** (1951), pp. 135-40.

This is the fourth of a series of articles on the design of packed distillation columns. The authors believe that the "transfer unit" concept is probably the soundest method theoretically, but that the method involves tedious mathematical procedure. The older h.e.t.p. concept may be of equal value and more practical for design purposes. An equation is given for estimating h.e.t.p. for Raschig ring packing in terms of reflux rate, viscosity, of reflux liquid, and diameter of Raschig rings. Columns with Raschig rings ordinarily have 0.3 to 1.0 inches of water pressure drop per theoretical plate. For difficult separations involving many plates operating at low pressure, the gauze-type packing may be most satisfactory because of the low pressure drop. Berl saddles show a larger allowable vapor rate for a given h.e.t.p. than Raschig rings. It is probable that about two thirds the volume required for Raschig rings would suffice for a given separation using saddles.

A Rotary Thermal Rectifying Column. EDGAR S. BYRON, JOHN R. BOWMAN, AND JAMES COULL. *Ind. Eng. Chem.*, **43** (1951), pp. 1002-10.

In thermal rectification, interphase transfer is effected by addition of heat to the reflux or abstraction of heat from the vapor, or both, causing partial vaporization, partial condensation, or both, respectively. The column used comprises two concentric tubes, the outer one heated and the inner one cooled and rotated on its axis. The vapor rises in the annular space between the tubes, and reflux flows as a falling film on the inner surface of the outer tube. The condensate so formed is immediately thrown outward centrifugally as a spray, to join the reflux stream. Enrichment occurs largely from the partial vaporization and condensing actions, not from spontaneous interphase transfer of material tending to approach equilibrium. The column is thus not a countercurrent contactor. The main advantage of such a column over conventional types is that it can be operated at low pressure.

Sulfur-Resistant Catalysts for Reforming Propane. Method for Rating Catalytic Activity and Sulfur Resistance. J. J. S. SEBASTIAN AND C. H. RIESZ. *Ind. Eng. Chem.*, **43** (1951), pp. 860-6.

A method was developed for rating the activity and resistance to sulfur poisoning of catalysts used for the steam reforming of hydrocarbons. Eleven most active and sulfur-resistant catalysts are listed in a table according to catalytic activity. Nickel in practically all forms was the most active catalytic material for reforming propane with steam. Nickel sulfide in about 1 to 2 molecular ratio on alumina was highly active and also resistant to sulfur poisoning. Nickel oxides were highly active, but variable in sulfur resistance. Reduced nickel was active, but has little sulfur resistance. Zirconia and thoria, used as promoters for nickel sulfide and nickel oxide catalysts, did not improve catalytic activity or sulfur resistance, but they did in-

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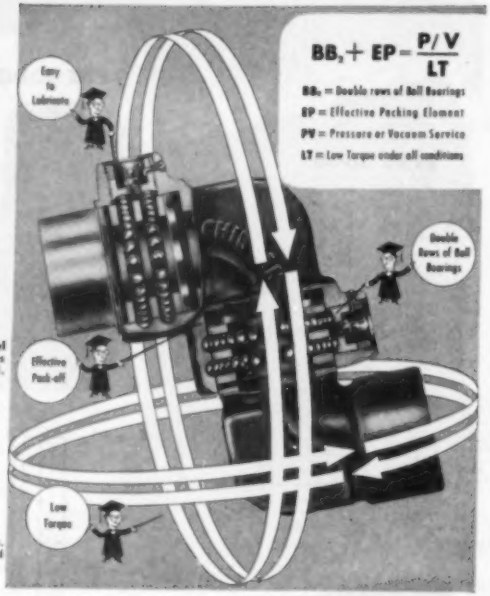
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crease mechanical strength. Compounds of iron and cobalt are less active than those of nickel. Chromium, molybdenum and tungsten were, in general, poorer than nickel and closer to iron and cobalt. Of all the mixed catalysts tried, the nickel sulfide-chromium sulfide-alumina combination was found best with respect to catalytic activity, sulfur resistance, and mechanical strength. However, none of the mixed catalysts were an improvement over the nickel sulfide catalyst on alumina supporting material.

Studies of the Fischer-Tropsch Synthesis. IX. Phase Changes of Iron Catalysts in the Synthesis. ROBERT B. ANDERSON, L. J. E. HOFFER, ERNST M. COHN AND BERNARD SELIGMAN. *Jour. Am. Chem. Soc.*, **73** (1951), pp. 944-6.

The study of phase changes in iron catalysts used in the Fischer-Tropsch synthesis is difficult because of unsatisfactory methods distinguishing between carbon as carbide, free carbon or other carbon containing material. The changes in a reduced fused-iron catalyst were studied using 1 H_2-to-1 CO gas at 7.8 atmospheres pressure in the Fischer-Tropsch synthesis. A method of analysis distinguishing between α-iron, low temperature carbide (Fe_2C), and cementite (Fe_3C) was used and depended on a combination of thermo-magnetic, X-ray diffraction and gravimetric analyses. In the first few days of the run α-iron was converted to Fe_2C. The content of this carbide increased to a maximum of 29 percent at 200 hours, and then decreased slowly throughout the remainder of the run. Magnetite was formed at a slower rate than Fe_2C, apparently chiefly at the expense of the α-iron phase. The magnetite phase increased throughout the entire run.

High-Pressure Fixed-Bed Catalytic Unit. G. B. ARNOLD, F. P. FRASCATI, AND N. D. CARTER. *Ind. Eng. Chem.*, **43** (1951), pp. 1013-8.

The authors describe a continuous fixed-bed catalytic unit designed to process a wide variety of petroleum stocks at moderately high pressures. Catalyst capacity was 320 ml., and the unit could operate up to 5000 pounds pressure at 538° C. In order to provide maximum adaptability, stainless steel was used extensively as a construction material. Data are given for a typical application of the unit, namely the hydrogenation of a high sulfur virgin gas oil. The details of the construction are given in several clearly made sketches, and a flow sheet and photograph of the unit are also included.

Pressure Drop in Fluidization Beds—Part I. O. P. AGARWAL AND J. ANDERSON STORROW. *Chem. and Ind.*, April 14, 1951, pp. 278-86.

The purpose of the investigation was to obtain quantitative information on the energy dissipated in maintaining the flow through the fluidized bed, the limiting gas rates for the state, and the effect of the particles on heat transfer rate between the gas stream and the retaining wall. Data are presented in considerable detail in tabular and graphical form. A bibliography of 43 references is included.

The Uniformity of Fluidization—Its Measurement and Use. R. D. MORSE AND

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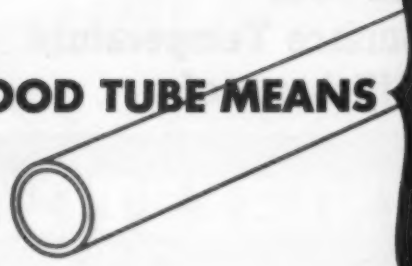

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Science and Technology

C. O. Ballou, Du Pont Company, Wilmington, Del. *Chem. Eng. Progress*, **47** (1951), pp. 199-204.

Uniform fluidization is characterized by well distributed particles forming fluid passages of uniform resistance, making fluid velocity also uniform across the cross section. Non-uniform fluidization is characterized by flocs or aggragates of particles boiling or being conveyed by fluid that flows primarily in the pockets or channels between clumps, so that fluid velocities vary widely from point to point and moment to moment. Capacitive methods of measurement have been useful in measuring phenomena difficulty measurable by other means, but in the past such equipment has been inflexible and expensive. However, the development of frequency-modulation broadcasting has made possible the easy and economic construction of a sensitive device to measure small capacitance changes. The details of the instrument are described. Materials of high electric conductivity, such as metal powders and graphite, cannot be tested with the capacitometer instrument.

Products: Properties, Utilization and Analysis

Stability of Fuel Oils in Storage. Effect of Some Nitrogen Compounds. R. B. Thompson, J. A. Chenicek, L. W. Druge, and Ted Symon. *Ind. Eng. Chem.*, **43** (1951), pp. 935-9.

The effect of small amounts of nitrogen compounds (of the type found in petroleum products) on the stability of fuel oils was studied, for it had been observed that filter and screen plugging precipitates are formed in furnace oils and frequently have significant amounts of nitrogen compounds in them. Of the substances studied, pyrroles were found to cause the largest formation of precipitates. The pyridine compounds were also harmful, but to a less extent than the pyrroles. Treatment of the oils with strong sulfuric acid removed the pyrroles, but caustic washing has little effect on them. Results of the work indicate one of the probable causes of precipitate formation, that is, a major source of complaint with regard to oils used in domestic oil burners.

The Stability of Mineral Oils in Toilet and Cosmetic Preparations. W. W. Myddleton. *Jour. Inst. Pet.*, **37** (1951), pp. 45-66.

Mineral oils are used in a wide variety of toilet and cosmetic preparations, including face-creams, hand-creams and lotions, sun-tan preparations, lipsticks, shaving-creams, and hair-dressings, and in emulsified as well as unemulsified states. Oils are valued for their bland emollient action on the skin, combined with lubricating properties and the property of imparting desirable physical characteristics to the preparations in which they are used. Preparations containing mineral oils deteriorate during storage under unfavorable conditions. This is caused in part by instability of the oils themselves. In order to determine stability characteristics, the oils and the emulsions made from them, were exposed to sunlight for four months and the order of deterioration thus estab-

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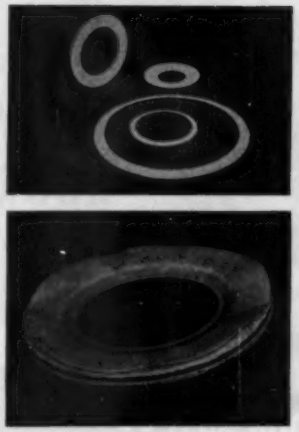

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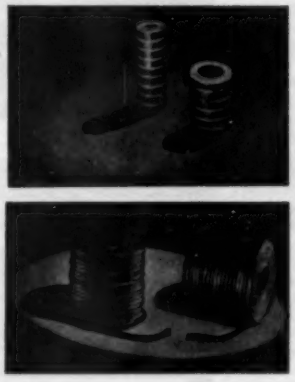

Pictured here are two of the many Teflon-"Chemiseal" packings fabricated by United States Gasket Company. Chemiseal #711 Teflon Packing (top) is particularly effective for rotating or reciprocating shafts operating under corrosive conditions. Shown below is Extruded Teflon Packing, Chemiseal #620EG or EM (impregnated with graphite or with mica)—a chemical-proof packing that's ideal for field maintenance or emergency use.

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Stiffness @ 77 F	60,000 psi.	Volume Resistivity	10^{18} ohm-cm.
Izod Impact Strength @: 70 F / 77 F / 170 F	2.0 ft.-lb./in. / 4.0 ft.-lb./in. / 6.0 ft.-lb./in.	Surface Resistivity @ 100% Rel. Hum.	3.6×10^{8} megohms
Durometer Hardness	55 to 70	Dielectric Constant, 60 to 10^{6} Cycles	2.0-2.05
Compressive Stress @ 0.1% Deformation	1700 psi.	Power Factor, 60 to 10^{6} Cycles	0.0005
Deformation under Load @ 122 F, 1200 psi., 85 hr.	4 to 8%	Water Absorption	0.0%
Coefficient of Linear Thermal Expansion from 77 to 140 F	5.5×10^{-5} per deg. F	Flammability	Nonflammable
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Science and Technology

lished. Stability was found to be well indicated by the levels of bromine substitution, aniline points, and the nature of the fluorescence of the oils in ultraviolet light. The article contains several interesting microphotographs and concludes with a bibliography of nine references.

Diffusion as a Rate-Limiting Factor in the Oxidation of Transformer Oils. R. Irving and C. N. Thompson. *Jour. Inst. Pet.*, **37** (1951), pp. 67-77.

In order to acquire knowledge of the effects of a limited availability of oxygen on the oxidation rate, several transformer oils and related products were oxidized under conditions that simulated those obtaining in a transformer in operation. Under these conditions the rate of oxidation is controlled by the rate of diffusion of oxygen into the oil. The course of the reaction was followed by measuring the rate of sludge and acidity development rather than the extent of the reaction after a fixed time. The reaction rates were significantly different from those observed in accelerated laboratory tests under similar conditions but with excess oxygen. Slower rates of oxidation were observed to result from limited oxygen access. The catalytic effect of soluble copper and iron on the oxidation rates of several oils were also studied. A soluble iron catalyst influences sludge formation to a less extent than does copper. A bibliography of 12 references is included.

Selenonophosphates as Lubricant Additives. Ray E. Heiks and Frank C. Croxton. *Ind. Eng. Chem.*, **43** (1951), pp. 876-84.

The purpose of the work was to extend the knowledge of selenium compounds as lubricant addition agents to another class of compounds, the selenonophosphates. Extensive bench and engine testing has shown that these phosphates act as antioxidants for lubricating oils, and also reduce bearing corrosion to some extent. The method of preparation of the selenonophosphates affects their performance as antioxidants and bearing-corrosion inhibitors. They are better antioxidants for lubricating oils than their sulfur analogs or the corresponding phosphites.

Fundamental Physical and Chemical Data

Isobaric Heat Capacities at Bubble Point. T. J. Connolly, B. H. Sage, and W. N. Lacey. *Ind. Eng. Chem.*, **43** (1951), pp. 946-50.

The purpose of the work was to extend the range of temperatures for which the heat capacities of organic liquids of industrial importance are available. Calorimetric measurements were made to establish the isobaric heat capacities at the bubble point for *n*-hexane, methylcyclopentane, and n-octane at temperatures from 80° to 200° F. The data secured were found to be in agreement with earlier measurements, and are believed of adequate accuracy for most engineering work. Data of this type are important in extending the range of temperatures for which free energies, enthalpies, and entropies of these compounds can be estimated. The heat capacity data,

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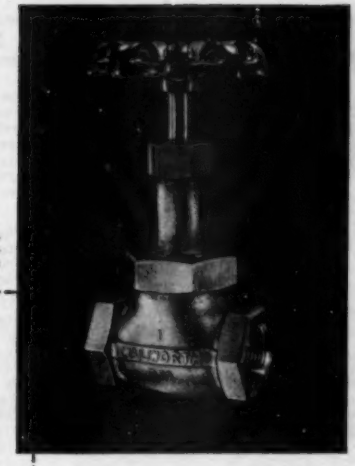

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when used with directly measured experimental volumetric data or suitable correlations, permit the thermodynamic properties to be determined as a function of state. Data are given in detail in tabular form and a bibliography of 18 references is included.

Phase Equilibria in Hydrocarbon Systems. H. H. Reamer, B. H. Sage, and W. N. Lacey. *Ind. Eng. Chem.*, **43** (1951), pp. 976-81.

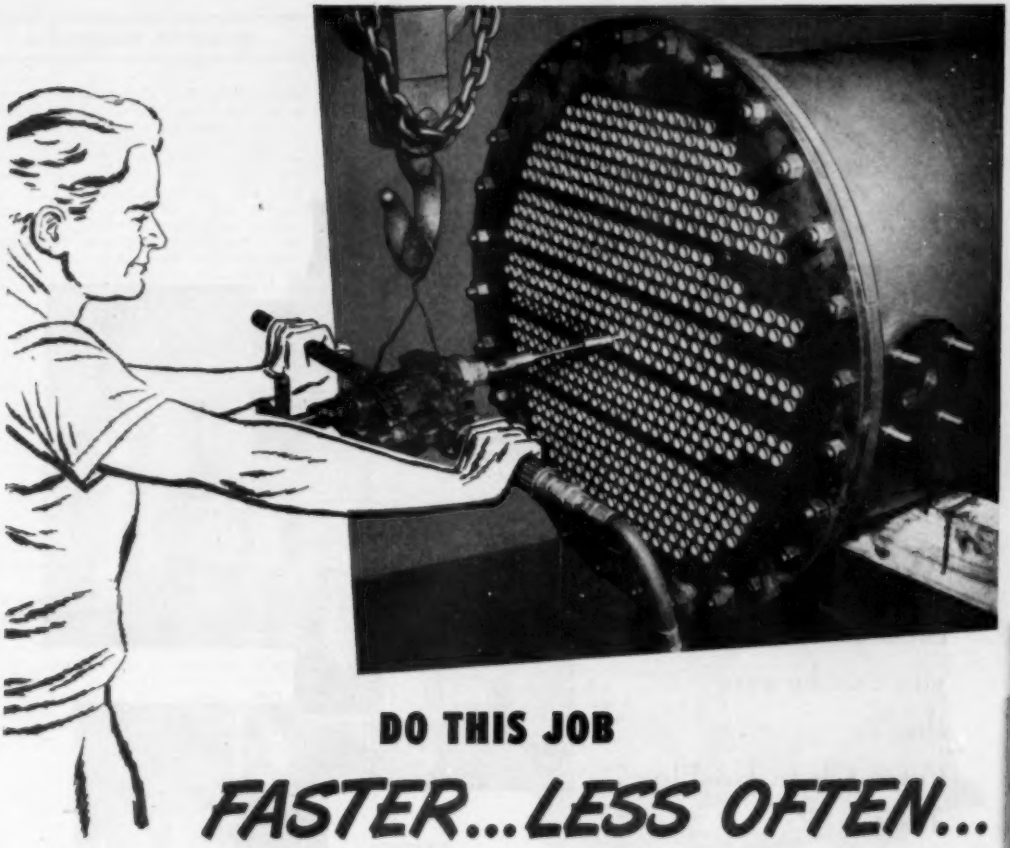
Hydrogen sulfide is an important component of the fluids produced from underground petroleum reservoirs, therefore, it is of importance to determine the volumetric and phase behavior of solutions of this compound and paraffin hydrocarbons. The molal volume of five mixtures of methane and hydrogen sulfide was determined at pressures up to 10,000 pounds per square inch in the temperature interval 40° to 340° F. The compositions of the coexisting phases were established throughout the heterogeneous region at temperatures above 40° F. The effect of temperature and pressure upon the molal volume of mixtures of methane and hydrogen sulfide was found to be similar to that for systems composed only of paraffin hydrocarbons. A maximum two-phase pressure of slightly less than 2000 pounds per square inch was encountered at a temperature of approximately 50° F. Before the correlation of the phase behavior of this compound can be completed, it will be necessary to obtain additional information about the compound in binary systems containing a paraffin hydrocarbon of higher molecular weight than *n*-butane. Data are presented in detail in tabular and graphical form and a bibliography of 14 references is included.

Net Heat of Combustion of AN-F-58 Aircraft Fuels. Simon Rothberg and Ralph S. Jessup. *Ind. and Eng. Chem.*, **43** (1951), pp. 981-5.

The work described was undertaken to determine whether the heats of combustion of volatile hydrocarbon liquids used as jet-propulsion fuels could be correlated with more easily measured properties of the fuels. Experimental measurements of the heats of combustion were made on 32 liquid fuels meeting the specifications for jet-propulsion fuels. It was found that these data and the data previously reported from the Bureau of Aeronautics on 57 aviation gasolines could be represented by a linear equation expressing net heat of combustion as a function of the product of aniline point in degrees F. and gravity in degrees API. In consequence of this it is possible to make reliable estimates of the heats of combustion of a variety of hydrocarbon fuels without the necessity of making experimental determinations, which are both difficult and time-consuming. Data are presented in tabular and graphical form and a bibliography of 19 references is included.

Properties of High Boiling Petroleum Products. L. T. Eby, G. G. Wanless, and John Rehner, Jr. *Ind. Eng. Chem.*, **43** (1951), pp. 954-60.

The objective of the work was to obtain a better knowledge of the distillation behavior of polynuclear aromatic



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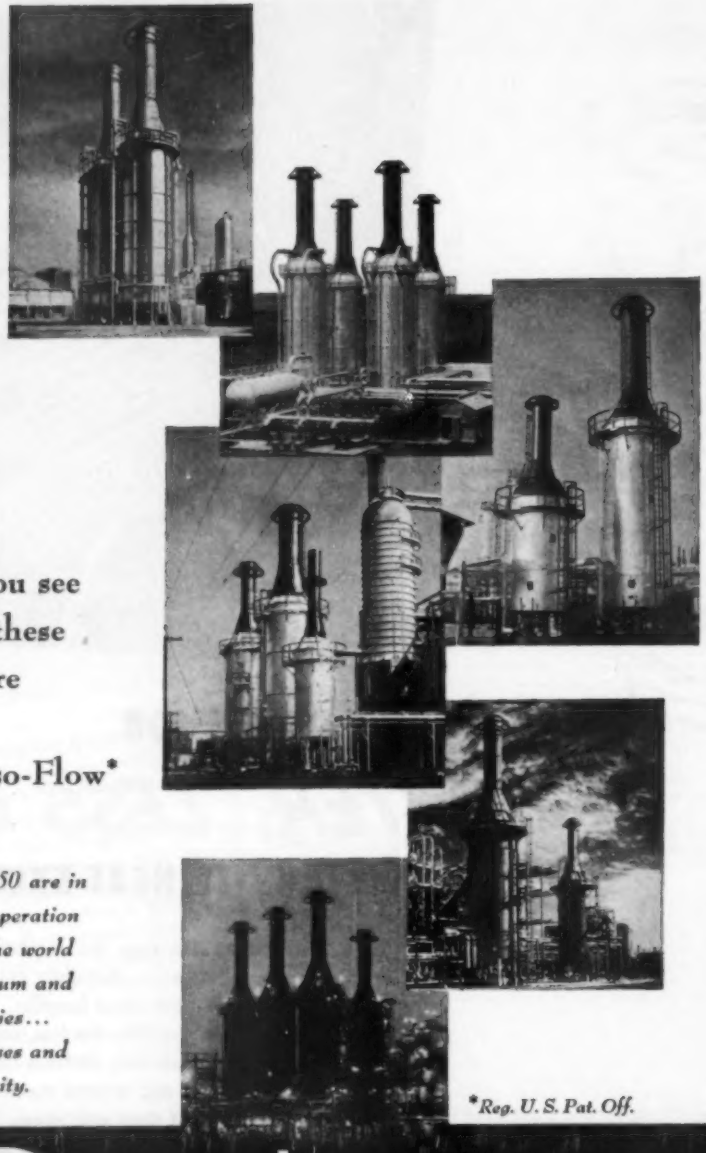

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compounds present in high boiling products. Materials studied were solutions of polynuclear aromatic compounds in high boiling nonaromatic and in aromatic petroleum oils. Typical of the compounds studied were pyrene, 3,4-benzopyrene, and 1,2,5,6-dibenzanthracene. The distillations were made in a simple still under near-equilibrium conditions. It was found that the relative volatilities of the solute hydrocarbons were higher in nonaromatic than in aromatic oils. A linear relationship was found between the atmospheric boiling point of a nonaromatic oil and the logarithm of the relative volatility of a dissolved polynuclear aromatic compound. The relative volatility of the dissolved aromatic compound is reduced to one third its value in going from a nonaromatic to a completely aromatic oil. To obtain equal amounts of the solute in the distillate, the atmospheric distillation temperature required for the aromatic oil is at least 50° higher than for the nonaromatic solvent. A method is described for estimating the boiling point of a polynuclear aromatic compound from the relative volatility data on the distillation fractions of an oil used as the solvent for such a compound.

Azeotrope Formation Between Sulfur Compounds and Hydrocarbons. D. H. Desty and F. A. Fidler. *Ind. Eng. Chem.*, **43** (1951), pp. 905-10.

The paper covers the subject of the properties of azeotropes formed between hydrocarbons and alkane sulphides, alkane disulfides, thiophenes, and a cyclic sulfide. A previous paper covered the subject of the sulfur alcohols or mercaptans and hydrocarbons. Sixty-three azeotropes were prepared and their properties and compositions determined. The results were correlated in a manner similar to that previously adopted for the thiols and hydrocarbons and the same relationships were found to exist. As a result of the work, it is now possible in many cases to predict whether azeotrope formation between a specific hydrocarbon and sulfur compound boiling in the gasoline range will occur and, if it does, to give the boiling point and composition of the azeotrope. Also a comparison was made of the strength of azeotrope formation with various classes of sulfur compounds. From this study it appears that azeotrope formation with hydrocarbons can be used as a means of separating individual sulfur compounds from mixtures such as are isolated from petroleum distillates. Data are presented in detail in tabular and graphical form, and a bibliography of five references is included.

Muschamp Named Chairman

Vice president in charge of engineering for Brown Instruments Division, Minneapolis-Honeywell Regulator Company, George M. Muschamp was elected chairman of the Philadelphia Section of the American Society of Mechanical Engineers at an ASME annual sectional meeting. Robert W. Worley of United Engineers and Construction, Inc., was elected vice chairman; James A. Quaid, Martin Quaid Company, was chosen treasurer, and C. C. Franck, Westinghouse Electric Corporation, was chosen secretary.

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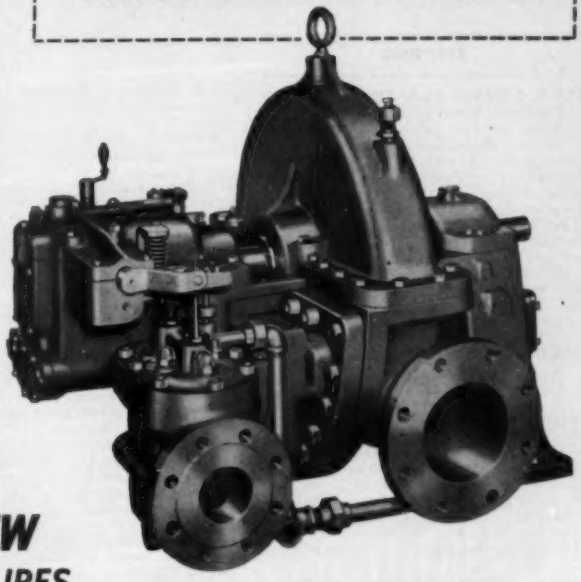

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Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, March 13, 20, 27 and April 3, 10, 1951)

REFINING

U.S.P. 2,544,912. Shale Distillation with Fluidized Residue Treatment. H. V. Atwell to The Texas Company.

In the distillation of oil shale, the pulverized or comminuted material formed is removed from the drilling zone before complete removal of its hydrocarbon or carbonaceous content. This material is fluidized and subjected to combustion to impart a high degree of heat to the material. The heated material is then fluidized with gas and the resultant heated gas is delivered to the retort for the destructive distillation of the shale.

U.S.P. 2,545,067. Adsorption Process. C. H. O. Berg and D. H. Imhoff to Union Oil Company of California.

A continuous process for separating a gaseous mixture into a plurality of fractions of varying degrees of adsorbability, e.g. for separating hyrogen from a hydrocarbon gas, or methane from natural gas, makes use of a moving bed of granular adsorbent, such as charcoal, flowing downward through a cooling zone and an adsorption zone. Details of the process are claimed.

U.S.P. 2,545,137. Corrosion Inhibitors. W. David to Shell Development Company.

A light petroleum hydrocarbon fraction with a b.p. of 50-370° C., contains 1-20 percent of a mixture of blown vegetable or fish oil, e.g. rape oil, and a waxy petroleum fraction, e.g. petrolatum, 0.1-10 percent of an alkali metal salt of a specific type of sulfonic acid, 5-10 percent of a ketoalcohol or cycloalcanol. The composition is useful in displacing moisture from and preventing corrosion of metal surfaces.

U.S.P. 2,545,138. Corrosion Inhibiting Compositions. W. David to Shell Development Company.

The corrosion- and rust-inhibiting composition according to this patent is closely related to that of U.S.P. 2,545,-137.

U.S.P. 2,545,199. Removal of Peroxides from Hydrocarbons. L. C. Fetterly to Shell Development Company.

Peroxides are removed from refined gasoline fractions, e.g. from cracked gasoline, free from H_2S and mercaptan acidic constituents and deteriorated during storage, by contacting the gasoline fraction with an aqueous alkali solution containing 1-15 percent by weight of added alkali metal sulfide for reducing said peroxides.

U.S.P. 2,545,806. Deashing Petroleum Residua. E. E. Davis to Sun Oil Company.

Petroleum residua containing alkaline naphthenates are mixed with 0.1-2 percent glycerine by volume. The mixture is treated at elevated temperature with H_2SO_4 in amount sufficient only to neutralize the residua. On vaporizing water from the treated residua inorganic salt crystals of relatively large size are formed which are removed to thus purify the residua.

U.S.P. 2,545,850. Adsorption Process and Apparatus. D. H. Imhoff to Union Oil Company of California.

In a continuous process for the separation of gaseous hydrocarbon mixtures, e.g. for the recovery of C_3 hydrocarbons from their mixture with other gaseous hydrocarbons, by selective adsorption and desorption, with the use of a moving bed of granular adsorbent, the stripping of the adsorbed components from the enriched adsorbent is carried out in a plurality of stages. In one stage the enriched adsorbent is heated to stripping temperature and contacted with relatively small amounts of stripping gas, while in a subsequent stage the heated, partially stripped adsorbent is contacted with relatively large amounts of this gas.

U.S.P. 2,546,125. Fuel Oils for Gas Turbine Engines and Process of Making Same. D. A. Howes to Anglo-Iranian Oil Company, Ltd.

A petroleum residue fraction constituting not more than 30 percent by volume on the crude petroleum and containing a vanadium compound in an amount of at least 0.03 percent V is combined with at least 500 percent by volume of a solvent containing hydrocarbons with 3-7 C. atoms. The insoluble material formed is separated from the solution, whereupon the desired fuel oil containing the V-compound is recovered from this solution.

U.S.P. 2,546,349. Apparatus for Distillation of Gasoline Containing Hydrocarbon Fractions. L. P. Scoville to The Texas Company.

The construction is claimed of an apparatus for stabilizing and fractionating petroleum products, such as cracked naphtha, and for converting low-boiling or normally gaseous effluents of such stabilization and fractionation to gasoline hydrocarbons of high anti-knock value.

U.S.P. 2,546,677. Microcrystalline Wax as an Antifoam Agent in Soluble Oil-Water Emulsion. E. H. Sperry to Sun Oil Company.

A major proportion of a mineral oil is mixed with a minor proportion of a soap to impart miscibility with water to it. Microcrystalline wax with a m.p. of 145-200° F. and a mol weight of 500-850 is added to a small proportion of the soap to inhibit excessive foaming of the emulsion formed on addition of water.

U.S.P. 2,547,188. Process and Reagents for Resolving Emulsions. T. B. Wayne, Houston.

Petroleum emulsions are resolved by a water-wettable, interfacial and surface-active condensation product of a polybasic carboxylic acid and a hydroxylated amino compound derived initially by interaction between a detergent-forming acid and a hydroxy amine.

U.S.P. 2,547,612. Method and Centrifuge for Dewaxing Oil Solution. G. H. Anderson to Aktiebolaget Separator-Nobel, Stockholm.

Details are claimed of a process and centrifuge for continuously separating wax from its mixture with an oil solution heavier than the wax.

U.S.P. 2,547,629. Process of Refining Mineral Oils. B. K. Engel and F. T. E. Palmquist to Aktiebolaget Separator-Nobel, Stockholm.

Lubricating oils are refined by first introducing fresh conc. H_2SO_4 into a stream of the oil under special conditions of forming and treating a pre-refined raffinate phase which is then subjected to a secondary refining by the action of the acid contained therein.

U.S.P. 2,547,970. Controlling Heating Valve of Natural Gas. W. L. Phillips and C. P. Stanley to Phillips Petroleum Company.

Details are claimed of a method of producing a residue gas of predetermined Btu. content and a deethanized natural gasoline from a natural gas containing gasoline hydrocarbons and hydrocarbons of lower boiling range.

U.S.P. 2,548,032. Process for Increased Olefin Recovery in a Petroleum Refinery. D. M. Little to Phillips Petroleum Company.

The recovery of C_3, C_4 and C_5 olefins from a mixture of hydrocarbons also containing other hydrocarbons, such as

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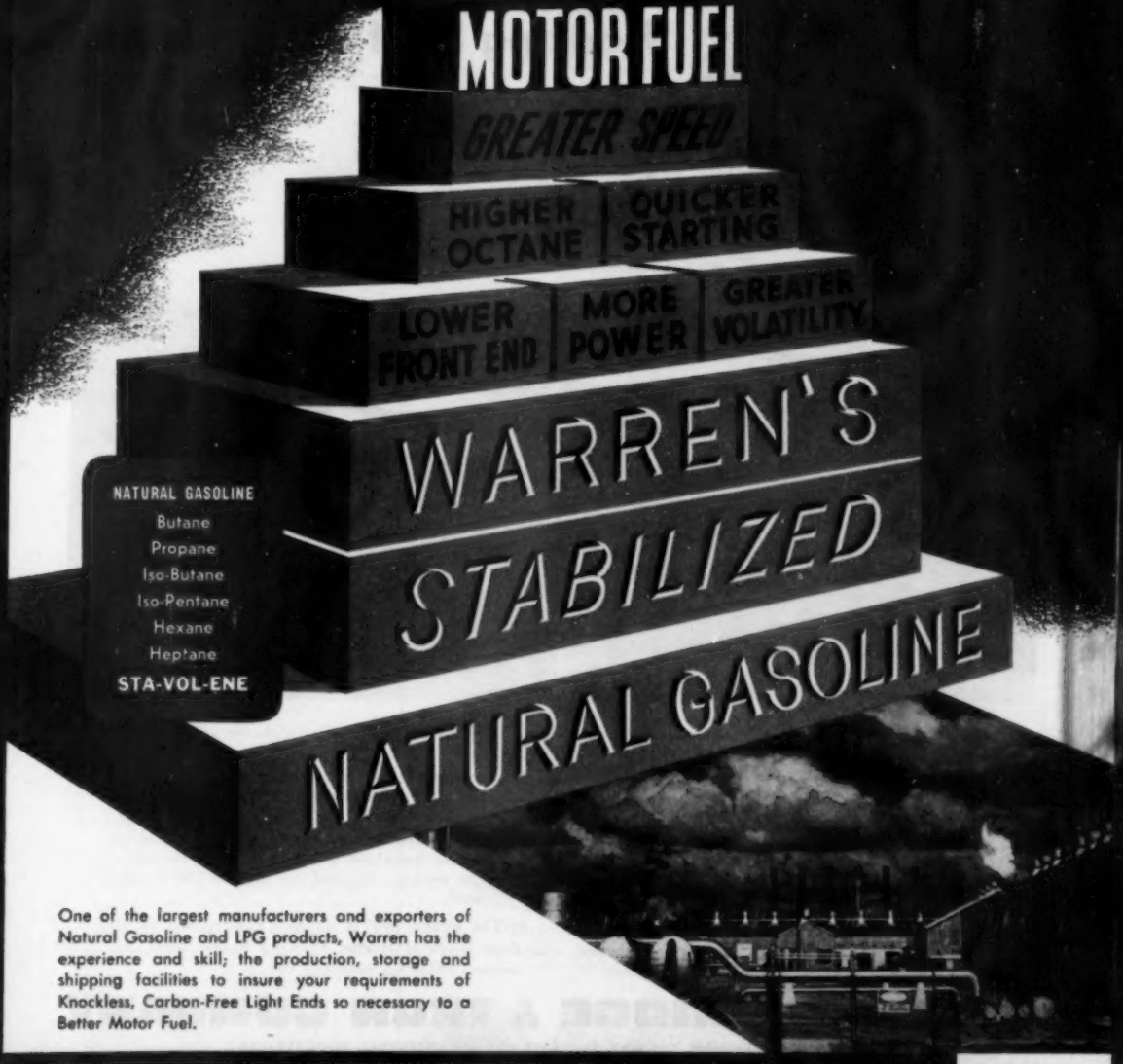

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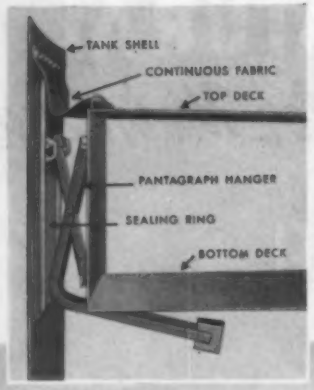

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Horton Steel Works, Limited, Fort Erie, Ontario, Canada
Motherwell Bridge & Engineering Company, Limited, Motherwell, Scotland
Whessoe, Limited, Darlington, England
Comprimo N. V., Amsterdam—O, Netherlands

a thermally cracked straight run naphtha fraction or the like, is obtained by a fractionating process claimed in detail.

U.S.P. 2,548,058. Rich Oil Distillation. E. G. Ragatz, San Marino, Calif.

A method is claimed for separately removing undesirable low boiling hydrocarbons, e.g. ethane, and desired higher boiling hydrocarbons, e.g. propane, from rich adsorption oil.

U.S.P. 2,548,122. Corrosion Inhibited Gasoline. T. C. Roddy, Jr., to The Texas Company.

A gasoline from a high-sulfur crude containing 0.5-10 pounds per 1000 barrels of a 2,2-dibenzothiazol disulfide compound. The additive renders the gasoline noncorrosive to metal.

U.S.P. 2,548,192. Adsorption Process and Apparatus. C. H. O. Berg to Union Oil Company of California.

A continuous selective adsorption process for the separation of gaseous mixtures is claimed in detail, such as for the separation of atmospheric air containing CO_2, water, and hydrocarbons, by means of granular charcoal or the like.

U.S.P. 2,548,347. Fuel Oil Composition. J. B. R. Caron, E. B. Glendenning, and C. Wies to Shell Development Company.

A fuel oil which contains substantial amounts of cracked components and entrained moisture and has a normal tendency to cause clogging is rendered non-clogging by incorporation of 0.0025-0.005 percent of a partial ester of polyethylene glycol oleate or of sorbitan monolaurate.

U.S.P. 2,548,498. Production of Dry Ice from Natural Gas. R. P. Russell and W. H. Rupp to Standard Oil Development Company.

Dry ice is produced from petroleum oil and natural gas well fluids by separating these fluids into at least a C_1 and a C_3 fraction and burning the C_1 fraction with oxygen of at least 95 percent purity. The resulting CO_2 is liquefied. The C_3 fraction is contacted after purification and in liquid phase with the liquefied CO_2 at a pressure of 300-1100 psi. and the then withdrawn liquid CO_2 is further treated to produce CO_2 snow.

U.S.P. 2,548,499. Carbon Dioxide Purification Process. W. H. Rupp to Standard Oil Development Company.

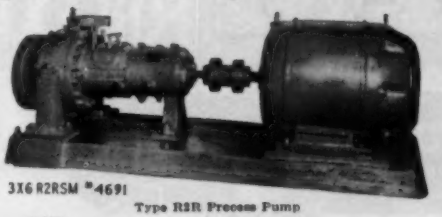
Impure liquid CO_2 is purified of sulfur compounds, water and heavy oils by treatment with liquefied C_3 hydrocarbons.

U.S.P. 2,548,502. Fractionation with Solid Adsorbents in a Single Column. J. K. Small to Standard Oil Development Company.

An intermediate fraction, e.g. a C_3 fraction, is concentrated from a mixture of hydrocarbon vapors containing lighter and heavier fractions, e.g. a mixture of C_2-C_4 hydrocarbons, by feeding the mixture to a downwardly moving column of solid adsorbent. The adsorbent is then heated in a desorption zone at a point above the feed point. The desorbed intermediate fraction is withdrawn as a

DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



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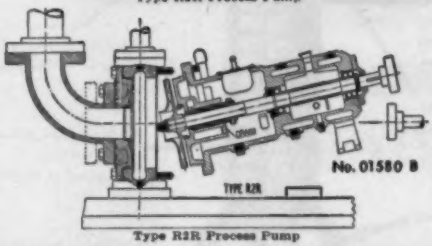
Type R2R Process Pump



Type R2R Process Pump

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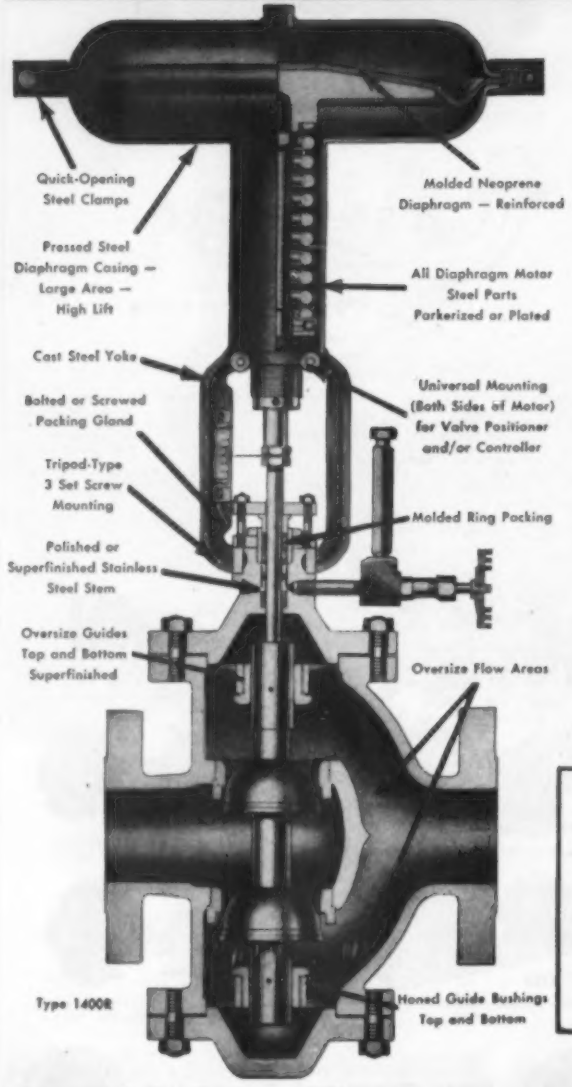
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side stream. Further treatment is also claimed.

U.S.P. 2,548,619. Removal of Acetylene from Hydrocarbon Mixtures. G. C. Ray to Phillips Petroleum Company.

A gaseous hydrocarbon mixture is freed of acetylene by adding to this mixture an amount of oxygen slightly in excess of that required to completely oxidize the acetylene, and then passing the mixture over a catalyst comprising porous alumina, MgO, CaO, or BaO at a temperature of 300-500° C.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,544,756. Fe_2O_3-Cr_2O_3-CuO Hydrogenation Catalyst. H. R. Guest and R. W. McNamee to Union Carbide and Carbon Corporation.

A hydrogenation catalyst consists of the mixed oxides of Fe, Cu, and Cr. The metals are present in a ratio of 71-109 parts of Cu and 8-17 parts of Cr per 100 parts of Fe.

U.S.P. 2,544,771. Copper-Chromium Hydrogenation Catalyst. D. M. Young, F. G. Young, Jr., and H. R. Guest to Union Carbide and Carbon Corporation.

A hydrogenation catalyst comprises the oxides of Cu and Cr in a ratio of 9-15 parts of Cr metal on 100 parts of Cu.

U.S.P. 2,544,869. Preparation of a Silica-Magnesia Catalyst. G. M. Webb, R. W. Moehl, and M. J. Murray to Universal Oil Products Company.

Silica hydrogel is mixed with a sufficient amount of MgO to form a final catalyst composite containing 20-40 percent of MgO. The mixing is carried out in the presence of an added solution of an ammonium salt water containing 0.05-1 mol of this salt per mol of MgO and having a pH below nine. The dried and calcined catalyst obtained contains very few fines.

U.S.P. 2,545,041. Temperature Control in Regeneration of Contact Agents. J. W. Moorman and L. J. Kelly to The M. W. Kellogg Company.

Details are claimed of a process for regenerating spent conversion catalyst from a continuous hydrocarbon conversion operation wherein the oxygen-containing regenerating gas is passed upwardly through the mass of spent catalyst as such a velocity that the solids are maintained in a fluidized state and an interface is maintained between a lower dense phase and an upper light phase thereof. A portion of catalyst withdrawn from the dilute regeneration phase is cooled and recycled to the dense phase.

U.S.P. 2,545,162. Method of Detecting Incipient Afterburning During Regeneration. W. Muly and J. J. Heigl to Standard Oil Development Company.

In the burning of combustible deposits from solid particles, e.g. spent hydrocarbon conversion catalysts, in a fluidized regeneration system having a dilute

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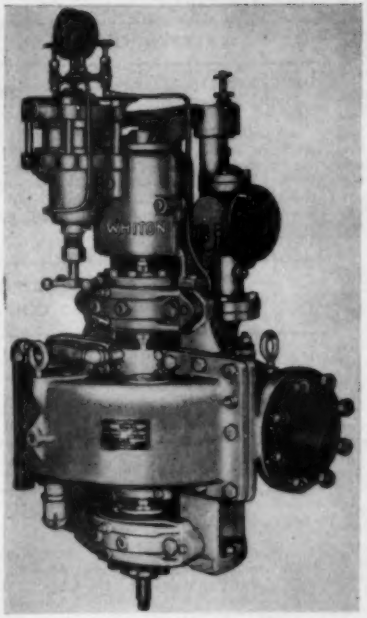

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phase of the fluidized particles, the rate of change of CO present in this phase is determined, and the temperature of this phase is decreased whenever the rate of CO change exceeds 0.1-0.2 percent per minute for a period of time greater than about 2½ minutes.

U.S.P. 2,546,031. Regeneration of Alumina-Chromia Catalyst. G. H. Hanson to Phillips Petroleum Company.

A dehydrogenation alumina-chromia catalyst is regenerated by contacting the spent catalyst with oxygen-containing gas having a steam content of 10-25 volume percent.

CRACKING AND REFORMING

U.S.P. 2,546,234-5. Catalytic Conversion of Hydrocarbon. H. L. Pelzer to Sinclair Refining Company.

Vaporized heavier hydrocarbons are heated in admixture with a catalyst consisting solely of anhydrous NH_4Br or NH_4F to a temperature of 720-820° F. at atmospheric pressure. Lighter hydrocarbons are obtained by this cracking operation.

U.S.P. 2,546,272. Conversion of Hydrocarbons Using Ammonium Iodide Catalyst. H. L. Pelzer to Sinclair Refining Company.

The process of this patent differs from U.S.P. 2,546,234-5 only in that NH_4I is here employed as the sole catalyst.

U.S.P. 2,547,021. Catalytic Cracking of Hydrocarbons and Apparatus Therefor. R. C. Lassiat, G. H. Kelso and J. E. Evans to Houdry Process Corporation.

In a cyclic process for the catalytic cracking of hydrocarbons in the presence of a static bed of catalytic contact material combined with regeneration of spent catalyst, the hydrocarbons are passed under cracking conditions through a bed of selected heat capacity of at least 0.45 Btu. per liter per degree F. The contact mass consists of 40-90° percent of siliceous cracking catalyst and 10-60° percent of an inert refractory material of high volumetric heat capacity. A heat exchange fluid is continuously flowed in a manner claimed in detail for removing heat from the contact mass during the entire cracking and entire regeneration periods.

U.S.P. 2,547,036. Hydrocarbon Conversion Processes with Acid-Treated Clay Catalysts. G. A. Mills to Houdry Process Corporation.

Normally liquid hydrocarbons are contacted under cracking conditions with a modified acid-treated clay containing magnesia free of alkali compounds and containing less than 0.4 percent of iron compounds calculated as Fe_2O_3. The catalyst has been heated to above 1425° F. A gasoline of improved anti-knock qualities is obtained by fractionation of the reaction effluent.

U.S.P. 2,547,221. Catalytic Reforming of Hydrocarbons in the Presence of Hydrogen. E. T. Layng to The M. W. Kellogg Company.

In the reforming of hydrocarbon in the presence of a reducible metal oxide catalyst of Group VI of the periodic system carried on an alumina-containing base and added free hydrogen, the catalyst is subjected after regeneration to a purging operation with free hydrogen or the like at pressures substantially less than those employed during the reforming operation.

U.S.P. 2,547,900. Fluidized Catalytic Cracking System with Rotating Disk Slide Valve. E. V. Bergstrom to Socony-Vacuum Oil Company, Inc.

The construction is claimed of a continuous catalytic cracking system wherein the outlet of a vessel (reactor and/or regenerator) containing particle-form material is sealed.

ALKYLATION

U.S.P. 2,545,671. Alkylation of Aromatic Hydrocarbons. H. J. Passino to The M. W. Kellogg Company.

An olefin-containing gas is reacted with an aromatic hydrocarbon by HF-vapor promoted by BF_3 at a temperature at which the reaction proceeds without substantial polymerization (preferably not over 200° F.), and at a pressure to maintain the HF and BF_3 in the vapor phase at the temperature employed.

U.S.P. 2,546,180. Method of Making Motor Fuel. S. B. Wiezer, Washington, D. C.

A mixture of olefins and an excess of methane is passed over a catalyst comprising $AlCl_3$ and Ni or Pt metal on a carrier at a temperature of 400-800° F. and a pressure of 60-100 atmosphere. Branched chain paraffins are obtained by this alkylating operation useful for preparation of 100 plus aviation fuels.

U.S.P. 2,548,803. Catalytic Process. E. L. Little, Jr., to E. I. du Pont de Nemours & Company.

In the preferential alkylation of cyclic unsaturated hydrocarbons, a monoolefinic hydrocarbon is contacted with a cyclic hydrocarbon unsaturated solely in the ring at a temperature of 0-130° C. and a pressure of 100-3000 atmosphere in the presence of an organo-alkali metal catalytic compound. The cyclic hydrocarbon employed shall contain at least one H atom directly attached to a saturated C atom singly bonded to a ring C atom which is in turn doubly bonded to one of the adjacent ring C atoms. Alkali metal alkyl and aryl compounds are the preferred catalysts.

POLYMERIZATION AND CONVERSION

U.S.P. 2,544,808. Dimerization of Butadiene. E. E. Stahly to Koppers Company, Inc.

Butadiene-1,3 is heated for a few minutes in liquid phase at a pressure of 40-1000 atmosphere to a temperature of 150-160° C. in the presence of a Cu or Cr naphthenate catalyst. The dimer 4-vinyl-cyclohexene-1 is obtained in a yield of more than 60 percent by weight of butadiene treated.

U.S.P. 2,545,144. Process and Apparatus for the Production of High Molecular Weight Polymers. A. D. Green and W. J. Paltz to Standard Oil Development Company.

A mixture of an iso-olefin with 4-8 C atoms, diolefins with 4-6 C atoms, and certain proportions of an ethylene or methyl chloride diluent is treated under specified conditions with a Friedel-Crafts catalyst solution at a temperature of —90° to —256° F. High molecule weight polymers are produced in a continuous manner.

U.S.P. 2,545,165. Gas-Solid Contacting Apparatus, Including Means for Stripping Solid Particles. H. J. Ogorzaly to Standard Oil Development Company.

The construction is claimed of an apparatus for stripping solid particles, particularly for stripping volatile hydrocarbons from adsorbent catalyst particles. An annular stripping section of the apparatus is divided into a plurality of vertically extending cells, and each cell is filled with spaced bundles of honeycomb or cellular cross-section.

U.S.P. 2,545,384. Insulation of Catalyst Chambers. A. R. Rehrig to Phillips Petroleum Company.

The construction is claimed of an apparatus for treatment of fluid materials by contact with solid contact material.

U.S.P. 2,545,522. Olefin-Dihydronaphthalene Copolymers. E. Lieber to Standard Oil Development Company.

A mixture of 70-99.9 percent by weight of an aliphatic mono-olefin having 3-5 C atoms and 30-0.1 percent of an unsubstituted dihydronaphthalene is copolymerized in the presence of a Friedel-Crafts catalyst at a temperature of below 0° C to —103° C.

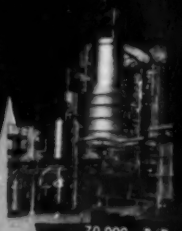
U.S.P. 2,545,702. Process for Preparing Stable Polystyrene Emulsions. F. H. Norris to Monsanto Chemical Company.

One hundred parts of styrene are polymerized under agitation in an aqueous medium containing 0.1-5 parts of an ammonium or alkali metal-salt of a copolymer of a vinyl ester of a lower aliphatic acid and maleic anhydride and 0.1-5 parts of a corresponding salt of a monocarboxylic aliphatic acid with 12-20 C atoms. Stable synthetic resin suspensions are obtained.

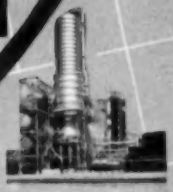
U.S.P. 2,546,020. Multiolefin Monoolefin Resin and Process of Making the Same. W. J. Sparks and J. D. Garber to Standard Oil Development Company.

A mixture of 30-55 percent of a multiolefin with 4-10 C atoms, such as butadiene, and 70-45 percent of a mono-olefin with 5-10 C atoms, such as diisobutylene, is cooled to —22° to +50° F. and polymerized in the presence of a fluid Friedel-Crafts catalyst. The polymerization is quenched at a conversion value not in excess of 75 percent of the monomers. A hard brittle resin of special characteristics is formed.

U.S.P. 2,546,042. Process and Apparatus for Catalytic Conversion of Hydr



crude distillation units



in any capacity

At the service of refiners:—Foster Wheeler's extensive know-how is available for the design and construction of all types of crude distillation units—both large and small.

A detailed description of a recently completed 63,000 barrel per day crude unit was presented in the April issue of Heat Engineering. Copies are available on request. Write for HE-4-51 to:

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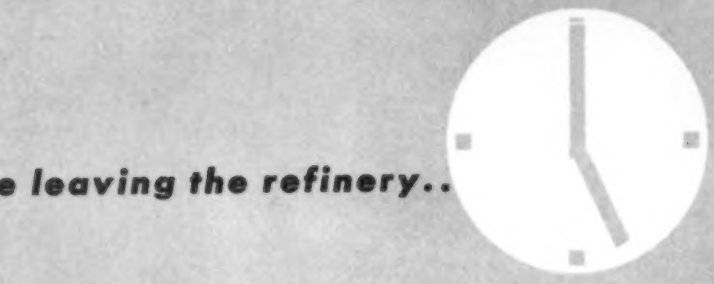

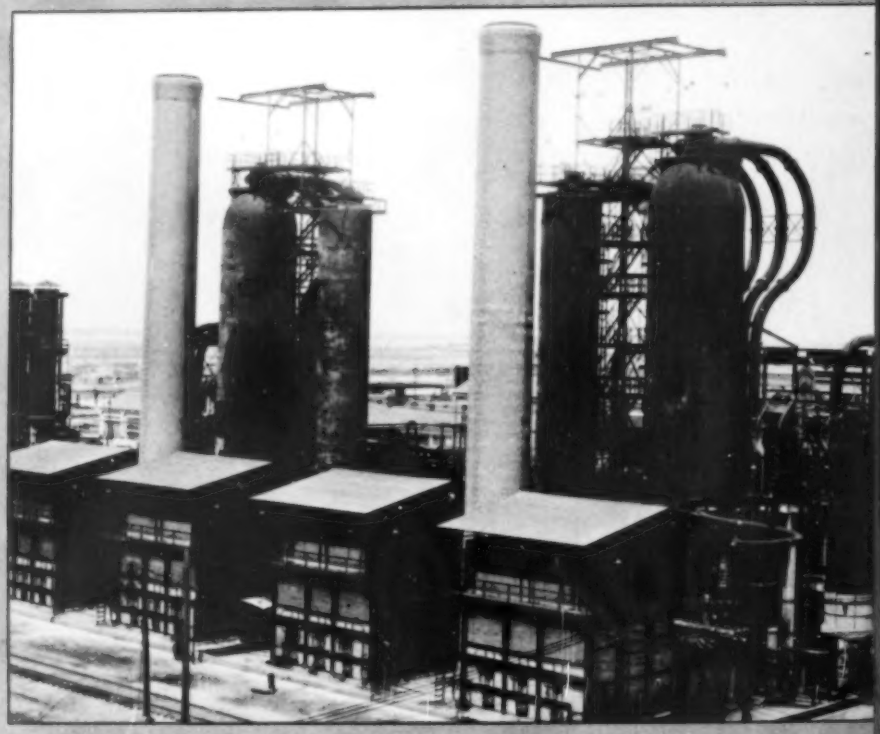

...it's a comforting feeling to know that these process units out there were designed 'right'... were built 'right'... and have a record of proven dependability.

The two two-stage crude distillation units in the photograph were designed and constructed by Foster Wheeler in 1931 *and they're still running... every day.*

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carbons. G. G. Oberfell and G. N. Cade to Phillips Petroleum Company.

In a process of catalytically converting hydrocarbons containing finely divided catalyst and regenerating the latter, the hydrocarbon stream in the conversion zone is heated by the hot regeneration gases passing in a helical path around the hydrocarbon stream.

U.S.P. 2,546,044. Catalyst Chamber Construction. C. L. Rogers to Phillips Petroleum Company.

The construction is claimed of an improved catalyst chamber for alternate conversion of hydrocarbons and reactivation of catalyst.

U.S.P. 2,546,220. Emulsion Polymerization with a Catalyst Comprising a Diazo Thioether and a Fericyanide. C. F. Fryling and W. B. Reynolds to Phillips Petroleum Company.

An aqueous emulsion of an unsaturated monomaric material containing an active $CH_2 = C <$ group, such as a major amount of butadiene-1,3 and a minor amount of styrene, is polymerized at a temperature of 0° to —30° C. in the presence of 0.05-2 parts (by weight of the monomeric material) of a diazo thioether of the formula R—N=N—S—R^1 where R is an aromatic radical and R^1 is an aromatic, cycloalkyl or aliphatic radical, 0.03-1 part of a water-soluble ferricyanide, 0.05-1.4 parts of an alkyl mercaptan with 6-16 C atoms, and 30-120 parts of methanol, ethylene glycol, glycerin, or erythritol. The products obtained show excellent retention of tensiles and extensibilities at elevated temperatures.

U.S.P. 2,546,244. Incremental Addition of Alkaline Material in Emulsion Polymerization. C. M. Tucker to Phillips Petroleum Company.

The process according to this patent is closely related to that of U.S.P. 2,546,220. The emulsion of the monomeric material is initially maintained at a pH of 9.5-11.5. The alcoholic material is not required here. During the polymerizing operation a plurality of increments of an alkali metal hydroxide, phosphate, carbonate, or pyrophosphate is added. Each increment shall be of an amount of 0.01-0.1 part per 100 parts of monomeric material. The addition of these increments allows the polymerization to be carried out over a wide temperature range.

U.S.P. 2,546,625. Method and Apparatus for Hydrocarbon Conversion. E. V. Bergstrom to Socony-Vacuum Oil Company, Inc.

Details are claimed of a method for conducting the conversion of hydrocarbons in the presence of a granular contact material passing downwardly through a confied contacting zone as a compact bed. The contact material is uniformly withdrawn from all portions of the cross section of the bed so as to promote uniform flow of contact material in the bed.

U.S.P. 2,546,634. Method and Apparatus for Contacting Gases with Particle Form Solid Material. L. P. Evans to Socony-Vacuum Oil Company, Inc.

Details are claimed of an apparatus and method for conducting gaseous reactions in the presence of a moving particle form solid material. The reactant gases are passed in parallel through a number of reaction stages.

U.S.P. 2,546,930. Process of Polymerization in the Presence of a Double Fluoride Catalyst. H. J. Passino to The M. W. Kellogg Company.

Olefins are polymerized in the presence of a double fluoride of HF and the fluoride of an alkali metal, alkaline earth metal, or ammonium.

U.S.P. 2,547,013. Reduction of Phosphoric Acid Corrosion in a Polymerization Process. J. D. Kemp and L. F. Brooke to California Research Corporation.

In the polymerization of normally gaseous olefins in the presence of liquid phosphoric acid in a polymerization zone presenting acid-resistant metallic surfaces, corrosion of these surfaces by phosphoric acid esters of the olefins formed during the process is decreased by maintaining the concentration of these esters in the reaction mixture below 0.08 mol of ester per mol of free phosphoric acid.

U.S.P. 2,547,015. Process for the Conversion of Hydrocarbons in the Presence of a Solid Particulate Contact material, Utilizing a Molten Metal as the Conveying Medium. C. G. Kirkbride to Houdry Process Corporation.

A fluent solid contact material, such

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as coke, in particulate form is continuously moved through a system comprising a contacting zone for conversion of a heavy hydrocarbon oil and a kinetic energy zone. The force necessary to cause the contact material to move through the system is applied to this material by injecting into the compact column of this material moving downwardly by gravity and having passed through the contact zone a downwardly directed stream of molten metal. The molten metal and commingled contact material flow through a U-shaped zone and the contact material which has been forced by the molten metal downwardly into the first arm of the U then rises in its second arm so as to accumulate a column of contact material extending to the top level of the system. A stream of molten metal solely is removed from a position of the second arm of the U. Kinetic energy is imparted to this stream for re-use.

U.S.P. 2,547,150. Polymerization of Butadiene Hydrocarbons in the Presence of a Trithiocarbonate. E. S. Blake and J. R. Durland to Monsanto Chemical Company.

A monomeric mixture of butadiene-1,3 and styrene is emulsion polymerized in the presence of less than 1 percent of a benzyl trithiocarbonate of the formula:

$$C_6H_{5-m}Cl_m—CH_2S—\overset{\overset{S}{\|}}{C}—S—R$$

wherein m is a number less than 4 and R is an alkyl or aromatic substituted alkyl radical.

U.S.P. 2,547,194. Shortstopping Agents in Emulsion Polymerization. F. B. Zienty to Monsanto Chemical Company.

In the emulsion polymerization of butadiene, a nitro substituted aromatic hydrocarbon thiocyanate containing not more than two nitro groups is added to the emulsion of the synthetic rubber at the end of the polymerization period to prevent additional polymerization of the monomers and cross-linking of the polymer molecules.

U.S.P. 2,547,380. Catalyst for Hydrocarbon Conversion. R. N. Fleck to Union Oil Company of California.

Hydrocarbons are subjected to conversion at a temperature of 800-1500° F. in the presence of a catalyst consisting of a major proportion of an inorganic metal oxide carrier and impregnated thereon 3-20 percent of a metal salt of a heteropoly acid, such as a salt of a phosphorous and/or molybedenum containing heteropoly acid.

U.S.P. 2,547,684. Plant for the Continuous Manufacture of Isoprene. P. M. Bourdon to Manufacture de Caoutchouc Michelin.

The construction is claimed of an apparatus for the continuous conversion of pinene or dipentene into isoprene by pyrolysis.

U.S.P. 2,548,015. Catalytic Hydrogenation and Apparatus Therefor. L. B. Goodson and J. A. Guyer to Phillips Petroleum Company.

Details are claimed of a method and apparatus for catalytically reacting at least two fluids together in a confined chamber.

U.S.P. 2,548,026. Apparatus for Pyrolytic Conversion of Hydrocarbons. O. G. Kaasa to Sinclair Refining Company.

The construction is claimed of an apparatus for the pyrolic conversion of hydrocarbons with the use of a finely divided solid catalyst. A more thorough and more uniform contact of the catalyst with the oil vapors to be converted is ensured by this apparatus.

U.S.P. 2,548,159. Group VIII Silicate Catalyst on Nonsiliceous Support. J. P. W. Houtman, W. F. Engel and P. van't Spijker to Shell Development Company.

A hydrogenation catalyst consists of a relatively inert, silica-free catalyst support, such as an aluminous carrier, a precipitated silicate of a metal of Group VIII, and a metal of Group VIII in association therewith. The amount of metal present as silicate shall be 0.5-60 percent of the total amount of this metal, and the total amount of the metal shall be 10-60 percent on the finished catalyst. The catalyst is highly active and long-lived and is particularly useful in Fischer-Tropsch synthesis operations.

U.S.P. 2,548,285. Method and Apparatus for Hydrocarbon Conversion. E. V. Bergstrom to Socony-Vacuum Oil Company, Inc.

In a cyclic process for the conversion of hydrocarbons with the alternative use and regeneration of a particle-form solid

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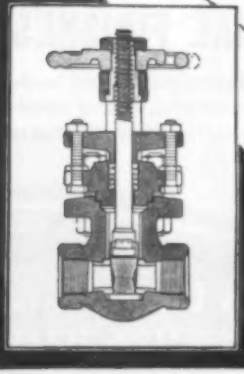

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contact material, contact material of varying particle size is contacted as a compact moving column with the fluid reactants and the contact material is supplied to this column across the entire horizontal cross-sectional area uniformly both with respect to particle size and amount.

U.S.P. 2,548,286. Method and Apparatus for Conducting Hydrocarbon Conversion Reactions. E. V. Bergstrom to Socony-Vacuum Oil Company, Inc.

Details are claimed of a process for effecting high temperature conversions of hydrocarbons with the formation of, for example, gasiform products which are unstable at the reaction temperature, and for rapidly heating reactants, generally, to reaction temperature. The supply of the heat, the effecting of the reaction and the quenching of the reaction products are all performed within a single chamber. The column of flowing granular contact material is maintained solely by supplying such material at the upper end of the column at a temperature substantially below the reaction temperature.

U.S.P. 2,548,295. Hydrocarbon Conversion and Catalyst Regeneration Apparatus. F. C. Fahnestock to Socony-Vacuum Oil Company, Inc.

The construction is claimed of an apparatus for conversion of hydrocarbons in the presence of a particle form catalyst. The multistage gas-solid contacting vessel is provided with improvements in gas distributing means and collecting means.

U.S.P. 2,548,318. Process for Preparing Polystyrene Dispersions. F. H. Norris to Monsanto Chemical Company.

One hundred parts of styrene are polymerized with constant agitation in an aqueous medium. This medium comprises an aqueous solution of 0.1-5 parts of an ammonium or alkali metal salt of styrene-maleic anhydride copolymer and 0.1-5 parts of such a salt of an aliphatic monocarboxylic acid with 12-20 C atoms. A stable synthetic resin suspension is formed.

U.S.P. 2,548,415. Boron Fluoride in Ethylidene Fluoride for Low Temperature Polymerization. L. M. Welch and H. L. Wilson to Standard Oil Development Company.

A mixed stream of a major proportion of isobutylene and a minor proportion of a diolefin with 4-14 C atoms, such as isoprene, is diluted with ½-10 volumes of ethylidene difluoride. The mixture is copolymerized by continuous addition of a liquid stream of a previously prepared BF_3 catalyst in ethylidene difluoride solution. The temperature is maintained at —40° to —103° C. The resulting copolymer is insoluble in this solvent and has a Staudinger mol weight above 20,000. The adhesion of the copolymer to the reactor walls is minimized by the presence of this solvent.

U.S.P. 2,548,486. Production of Industrial Gas. C. S. Lynch to Standard Oil Development Company.

Hydrocarbon gas is continuously fed to a reaction zone together with a finely divided mixture of 85-95 percent ZnO and iron or a reducible oxygenated iron compound. The rate of feed of this mixture is regulated in a special manner. A temperature of 1500-1700° F. is maintained. A CO-containing industrial gas is produced.

Patents

U.S.P. 2,548,519. Apparatus for Conducting High-Temperature Reactions. L. W. T. Cummings to Sun Oil Company.

The construction is claimed of a converter for conducting hydrocarbon conversion reactions at high temperature.

U.S.P. 2,548,522. Process for Heating Solid Granules. R. D. Drew to Socony-Vacuum Oil Company, Inc.

In a process for heating solid granules, the combustion gases produced are disengaged from the compact bed of granules at some point intermediate the ends thereof. An increase in temperature of the combustion gases is thereby permitted to a level at which the CO and other combustibles are largely consumed. The gases are then passed through a further portion of compact granular bed for further heat exchange.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,541,657. Method of Making Commercial Mixtures of Hydrogen and Carbon Monoxide. C. S. Lynch, T. B. Wasserbach, and W. R. F. Guyer to Standard Oil Development Company.

A normally gaseous hydrocarbon,

For complete specifications write for Bulletin 50.

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Patents

such as methane, is subjected to reforming in the presence of added CO_2 and steam and a reforming catalyst. A CO and H_2 containing product is collected. Another portion of the gaseous hydrocarbon is contacted in a first oxidation zone with a heavy metal oxide at elevated temperatures. The mixture of CO_2 and steam thus formed is conducted in part to the reforming zone while another part thereof is cooled to condense the steam. The remaining CO_2 is reduced in the presence of a fluidized bed of heavy metal to form CO. Reduced metal from the first oxidizing zone is conducted in part to this CO_2-reducing zone while another part thereof is oxidized and then returned to the first oxidizing zone. The product from the reforming zone is blended with the CO from the CO_2-reducing zone, while another part thereof is oxidized and then returned to the first oxidizing zone. The product from the reforming zone is blended with the CO from the CO_2-reducing zone to form a CO/H_2 mixture of the desired ratio.

U.S.P. 2,545,153. Preparation of Aromatics from Petroleum Distillates. E. T. Layng to The M. W. Kellogg Company.

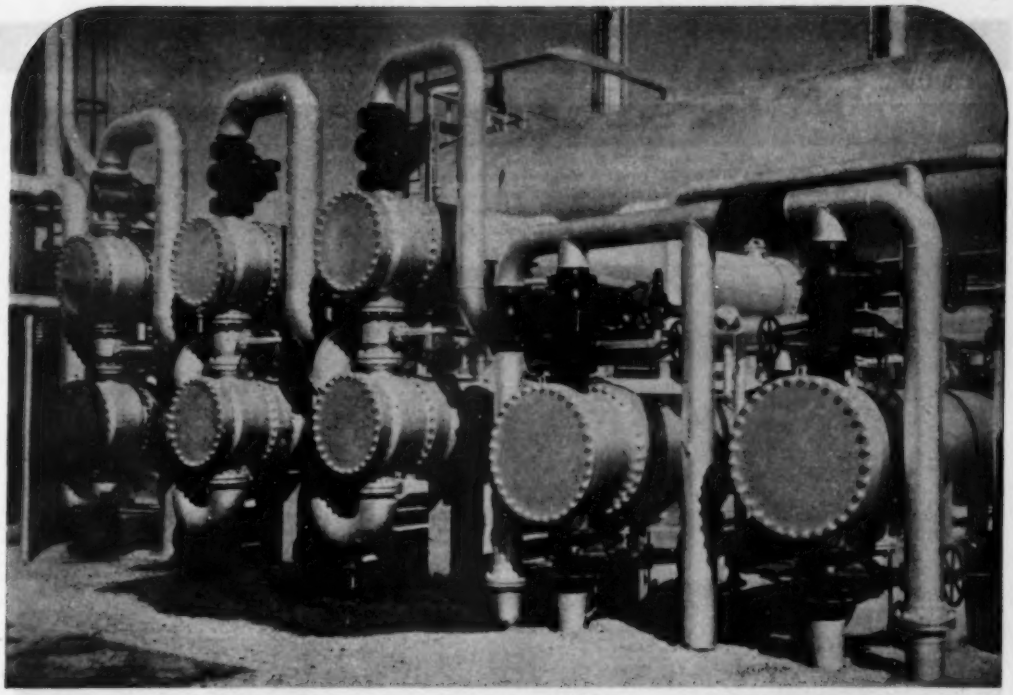
Substantially pure aromatic hydrocarbons, such as toluene, are produced by passing a naphtha including a large proportion of non-aromatics with 6-12 C atoms in the presence of added hydrogen in contact with a dehydrogenating and cyclicizing catalyst at elevated temperature. The reaction effluent is fractionated. A resulting fraction containing at least 50 percent of the desired aromatic hydrocarbon together with non-aromatics having at least 6 C atoms is passed at a temperature at least 50° F. higher than that of the first reaction step in contact with a similar catalyst in the presence of added hydrogen. The pure aromatic is separated from the resulting effluent by fractionation.

U.S.P. 2,545,954. Hydrocarbon Synthesis. W. G. Hockberger to Standard Oil Development Company.

A mixture of gasoline and gas oil constituents from a hydrocarbon synthesis in the presence of an iron base catalyst is contacted with bauxite at about 850° F., about 10 psig. pressure and a throughput of about 1 V/V/Hr., and on-stream periods of about one hour followed by refining catalyst regeneration periods. The resulting synthetic gasoline has octane numbers substantially above 80.

U.S.P. 2,546,017. Process for Hydrogenation of Carbon Monoxide. J. C. Schiller, S. R. Bethea and M. A. Mosesman to Standard Oil Development Company.

A CO/H_2 mixture is contacted with a catalyst initially comprising not over 10 percent of catalytic material susceptible to disintegration and formed by oxides or salts of iron, and a major amount of a solid zinc aluminate carrier with a high resistance to disintegration. The catalytic material is continuously introduced into the reaction zone separately from the carrier to maintain an amount not over 10 percent of the cata-



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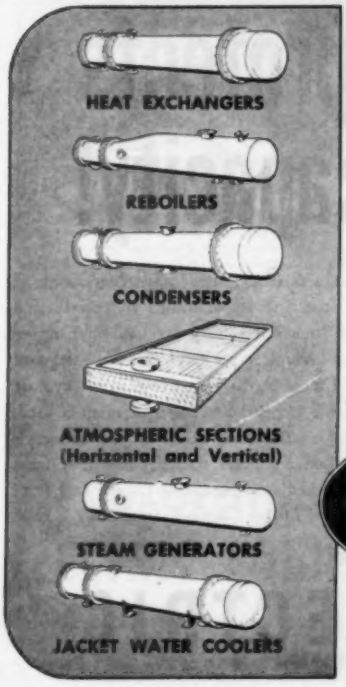

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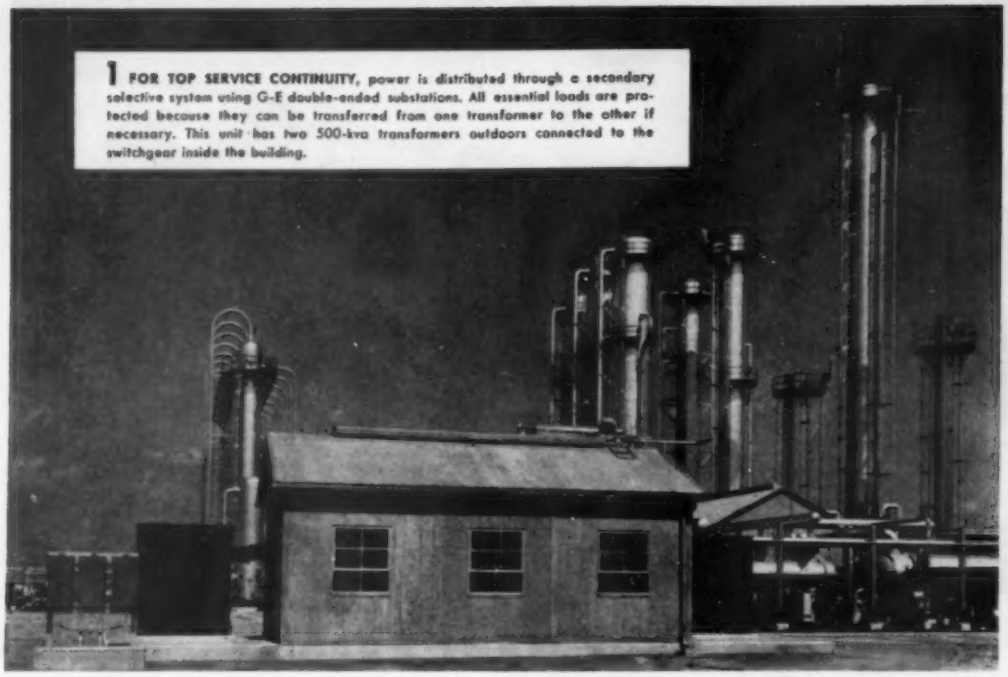
1 FOR TOP SERVICE CONTINUITY, power is distributed through a secondary selective system using G-E double-ended substations. All essential loads are protected because they can be transferred from one transformer to the other if necessary. This unit has two 500-kva transformers outdoors connected to the switchgear inside the building.

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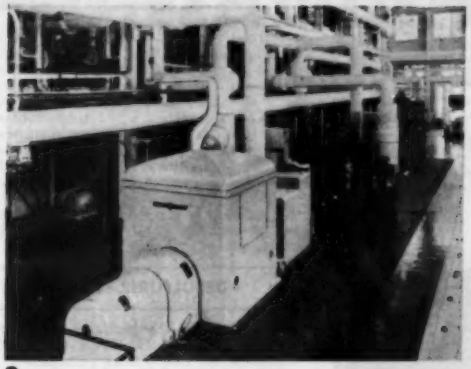
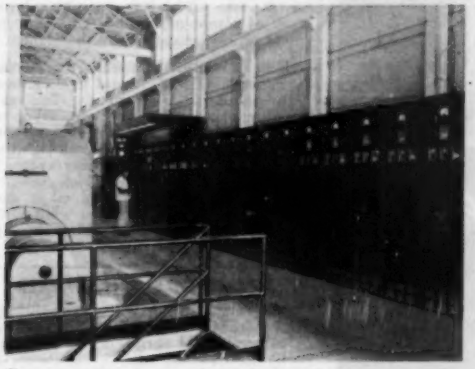
GENERAL ELECTRIC

661-26

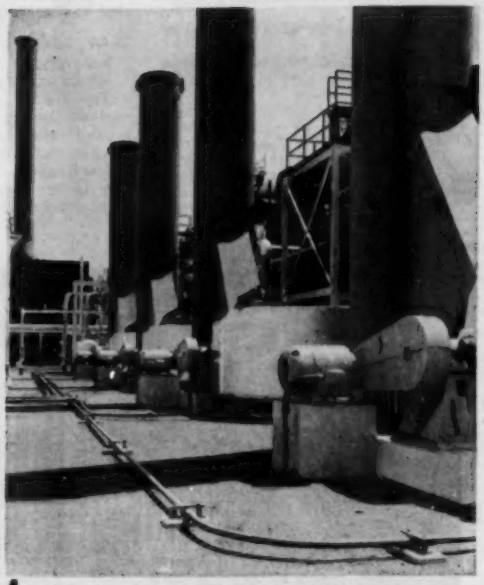


2 **DEPENDABLE POWER GENERATION** is provided by these two G-E turbine-generator sets, each rated 2500 kw, 4160 volts, with top-mounted generator coolers. The 6-stage turbines are rated 600 psig, 700 degrees F, 265 psig back pressure. G-E turbine-generators, designed for reliable operation, give maximum output per dollar of fuel cost.

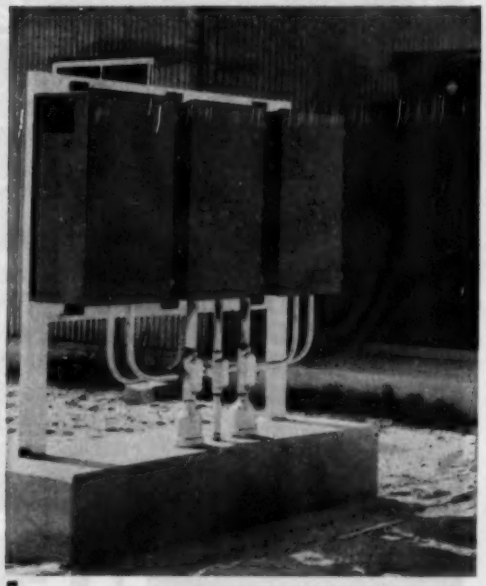


3 **COMPLETE CONTROL** of plant-generated power is supplied by this G-E 4160-volt metal-clad switchgear. Deadfront metal enclosures protect operating personnel. Circuit breakers—of adequate interrupting capacity for the plant's needs—are easily removable to simplify maintenance. Units are shipped assembled, ready for easy installation.

*Reg. Trade-mark of General Electric Co.



4 **3-WAY EXTRA PROTECTION** against physical damage, electrical breakdown, and operating wear and tear is built into these four G-E Tri-Clad* totally enclosed fan-cooled motors driving outdoor boiler fans in the Katy plant. Rated 75 hp, 440 volts, 1200 rpm, they have corrosion-resistant cast-iron enclosures to withstand acids, alkalis and solvents.



5 **TO PREVENT CORROSION** of piping, G-E rectifiers are used for cathodic protection. Giving longer life, lower maintenance costs, and reduced shutdown time, G-E selenium rectifiers incorporate corrosion-resistant, oil-immersed stacks which are hermetically sealed against contamination by moisture or fumes in the air.

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ELECTRIC EQUIPMENT
for Gas Cycling and Repressuring

lytic material on the carrier. The synthesis is carried out at a temperature of 350-800° F., and a pressure up to 800 psi.

U.S.P. 2,546,606. Synthesis Gas preparation. B. J. Mayland to Phillips Petroleum Company.

Pebbles passing through a heating zone are heated in an upper portion of this zone, while natural gas or a mixture of methane is cracked in a lower portion of the zone to deposit carbon on the pebbles. These pebbles are then contacted in a reforming zone with a mixture of natural gas, or the like, and steam in a mol ratio of carbon to natural gas to seam of 1:1:2. A CO/H_2 mixture of the mol ratio 1:2 is formed and recovered, while the pebbles are recycled to the heating zone.

U.S.P. 2,547,178. Carbonylation Catalyst Recovery. J. A. Spence to California Research Corporation.

The organic products of a catalytic carbonylation process containing entrained catalysts are contacted with an oxygen-containing gas at a temperature below the effective oxidation temperature of the organic products for a period of time sufficient to oxidize the entrained metal compounds into a recoverable form.

U.S.P. 2,548,801. Method of Forming Highly Active Catalytic Surfaces. J. E. Latta to Stanolind Oil and Gas Company.

A relatively thin highly active film of hydrocarbon synthesis catalyst is produced and maintained on the interior surfaces of a reactor by depositing thereon a thin film of a finely divided catalyst and a hydrocarbon binder consisting of a heavy hydrocarbon synthesis oil or melted hydrocarbon synthesis wax. In the hydrocarbon synthesis in the presence of this catalyst film, catalyst binder of the indicated type produced in the reaction is deposited on the surfaces and retains the catalyst as a thin film on its place.

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DESULFURIZATION

U.S.P. 2,546,345. Dethiolizing of Hydrocarbons. J. L. Meadows and J. N. Martin to The Texas Company.

Hydrocarbons containing sulfur compounds, such as mercaptans, are contacted for dethiolization with alkali metal hydroxide in a solvent of which the major portion consists of a glycol ether, such as methyl carbitol or methyl cellosolve, while the minor portion consists of an alkanol amine. The latter type of compound inhibits color impairment otherwise caused by the former.

U.S.P. 2,547,181. Distillate Sweetening Process. T. B. Tom and J. H. Krause to Standard Oil Company (Indiana).

Mercaptan containing hydrocarbon oil is sweetened by extracting the oil with an aqueous caustic-methanol solution until the major part of the mercaptans is removed. The mercaptan-rich solution is separated. The extracted oil is contacted with a free-oxygen containing gas to remove the last traces of mercaptan.

HEAVY OILS AND WAXES

U.S.P. 2,545,113. Addition Agents for Mineral Oil Lubricants. H. G. Smith, T. L. Cantrell, and J. G. Peters to Gulf Oil Corporation.

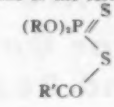
A mineral lubricating oil contains a minor amount of a product obtained by reacting an alkaline earth metal hydroxide and formaldehyde with aniline and a specific type of mono-alkyl phenols at elevated temperature. The additive confers bearing, corrosion inhibiting, and detergent properties to the lubricant.

U.S.P. 2,545,114. Lubricating Grease Composition. H. G. Smith and T. L. Cantrell to Gulf Oil Corporation.

The additive described in U.S.P. 2,545,113 is employed to stabilize against oxidation a grease composition obtained from mineral lubricating oil and a soap.

U.S.P. 2, 545,158. Oxidation Resisting Hydrocarbon Products. J. P. McDermott to Standard Oil Development Company.

A petroleum hydrocarbon product contains 0.02-10 percent of a mixed acid anhydride of the formula



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Reduce maintenance with D-F S-E* *Joints*

Shortages of manpower require you to build stamina in your lines. **Directed-Flexing Self-Equalizing*, an exclusive feature of Badger Expansion Joints, assures all-curve flexing in the corrugated member. Thus, localized flexing stresses cannot form . . . metal fatigue cut to a minimum . . . breakdowns are virtually eliminated.

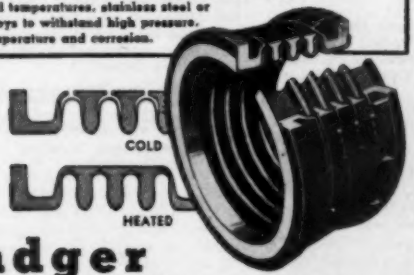
But that's not the whole Badger story. In addition to controlling the flexing movement *within* each corrugation, the specially designed Self-Equalizing Rings also control intra-corrugation movement. For unbeatable stamina be sure you get the exclusive Badger combination — Directed-Flexing Self-Equalizing — when you buy . . . specify Badger Expansion Joints for every job.

Only Badger Expansion Joints have Directed-Flexing Self-Equalizing rings which progressively control the movement of the all-curve corrugations.

Plus 5 other big features

- **Packless . . . pressure-tight single tube — requires no maintenance**
- **Compact . . . approximately the size of flanged fitting**
- **Special forming . . . no structure weakening stresses**
- **Controlled heat treating . . . assures long life**
- **Wide range of traverse — pressure — temperature**

Fabricated from deoxidized copper for normal pressures and temperatures, stainless steel or alloys to withstand high pressure, temperature and corrosion.



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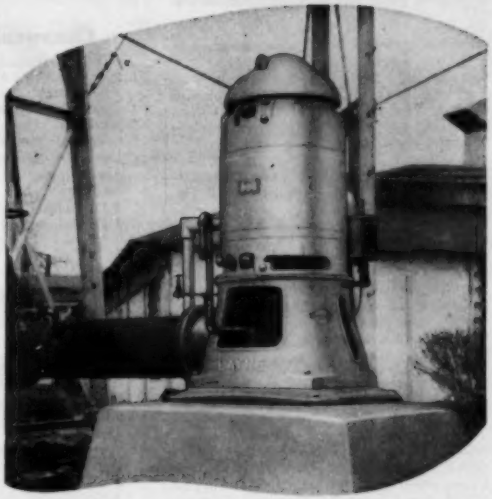

This is the 4th for a MEMPHIS INDUSTRIAL PLANT

THE FIRST IN 1934 IS STILL PRODUCING ITS ORIGINAL CAPACITY

Seventeen years ago, a big industrial plant in Memphis bought its first Layne well water supply system. World War II necessitated the installation of two more Layne water supply units. Now the fourth has just been completed and is producing 1790 GPM whereas the contract only promised 1500 GPM.

This is a typical case of where the first Layne installation proves to be so satisfactory that, as more water is needed, other Layne units are ordered as a matter of course. Certainly this industrial plant,—or any other big user of ground water, could make no finer investment.

Every Layne installation is a carefully engineered job from the original survey to the final testing. All have the same unmatched features of high efficiency, low upkeep cost and extra long life.

If you are in need of more ground water, a Layne engineer will gladly make a study of your conditions and recommend the type unit that will best serve your needs. No obligation. Write

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Patents

wherein R is an alkyl radical, such as isopropyl, and R' is an alkyl or phenyl radical. The additive imparts corrosion inhibiting properties to the hydrocarbon product, e.g. a lubricating oil.

U.S.P. 2,545,190. Alkali Base Lubricating Greases. A. A. Bondi to Shell Development Company.

A grease comprises a major amount of a mineral lubricating oil, 5-25 percent of an alkali metal soap, and 0.01-1 percent of a monohydrocarbyloxy polyethoxyethanol wherein the hydrocarbyl radical is an alkyl radical with 6-32 C atoms. The grease is mechanically stable, thermally reversible and non-bleeding.

U.S.P. 2,545,875. Sulfurzide Lubricant. G. N. Cade to Phillips Petroleum Company.

A HF-soluble hydrocarbon oil as obtained from a hydrocarbon alkylation process is reacted with elementar sulfur under special conditions. The sulfurized oil obtained imparts improved extreme pressure characteristics to lubricating oils.

U.S.P. 2,546,328. Carnauba Wax Substitute. K. G. Arabian and A. A. Schaerer to Shell Development Company.

A carnauba wax substitute consists of 30-70 percent each of a lubricating mineral oil and a mixture of straight-chain microcrystalline hydrocarbon waxes with molecule weights of 550-900, the major portion thereof having a molecule weight of 600-750. An aqueous wax emulsion of the oil-in-water type can also be obtained from these hydrocarbon waxes.

U.S.P. 2,546,552. Lubricants. C. M. Loane and L. W. Mixon to Standard Oil Company of Indiana.

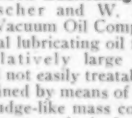
A hydrocarbon lubricant contains 0.001-10 percent of an alkali metal containing neutralized reaction product of a prosphorus sulfide and an olefin polymer having a mol weight of 500-10,000. This reaction product is obtained in a manner described in detail. The additve stabilizes the mineral oil against oxidative deterioration.

U.S.P. 2,546,916. Method of Refining Hydrocarbon Lublicating Oils. D. E. Badertscher and W. H. King to Socony-Vacuum Oil Company, Inc.

A residual lubricating oil fraction containing relatively large amounts of asphalt and not easily treatable by H_2SO_4 alone is refined by means of HF in liquid state. A sludge-like mass containing the asphalt compounds is formed by the treatment and associated with the HF, while refined hydrocarbons are recovered.

U.S.P. 2,546,941. Lubricating Oil. W. Davey to Shell Development Company.

A lubricating hydrocarbon oil contains not more than 10 percent by weight of a polyhalogenated acetal of the formula:



wherein X is S, Se, or Te; A is an organic radical having a plurality of halogen atoms, and each R_1 is an independently selected organic radical. Trichloromethyl di(thiaalkyl or benzyl) methane are examples of the additive. It imparts extreme pressure properties to the lubricant.

U.S.P. 2,547,396. Stabilized Paraffin Wax. M. A. Joanen to Sinclair Refining Company.

Paraffin wax is stabilized against oxidation by incorporation of .01-.04 percent of a liquid organo-silicon polymer of special properties and constitution.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

2,3,4-Trimethylhydroxybenzene
2,4,6-Trimethylhydroxybenzene
2-Nitro-4,5-dimethylaniline
Propyleneimine
Propylene sulfide
2,4,6-Trichlorotoluene
2,4,6-Trichlorostyrene
Benznaphthacene
4-Chloro-1,3-bis-(trifluoromethyl)-benzene
Copper thiocholine
2,4'-Diaminodiphenyl
2,5-Dichlorobenzene sulfonic acid
n-Hexacosane
Decamethylene dicarboxylic acid
para-Hydroxyphenylazide
p',p"-Dicyano-p-terphenyl
N-Methylthioacetamide
4-Bromocyclohexanone
Tridecamethylene bromohydrin

PETROCHEMICALS

U.S.P 2,545,161. Ethyl Alcohol Production. C. E. Morrell and R. F. Robey to Standard Oil Development Company.

Ethylene is passed into the lower portion of an absorption zone while concentrated H_2SO_4 is passed into the upper portion thereof. Both reagents are intimately contacted while maintaining progressively increasing temperatures of 65-82° C. in the upper and of 90-110° C. in the lower portion of the absorption zone.

U.S.P. 2,545,870. Catalytic Oxidation of Alkyl Benzenes to Produce Aryl Alkyl Ketones and Carbinols. G. A. Baker and W. Hunter to Celanese Corporation of America.

An alkyl benzene containing at least one alkyl group of more than one C atom in which the C atom next to the benzene nucleus is attached to hydrogen, e.g. ethyl benzene, is heated to above 100° C. in the liquid phase with at least an equimolecular amount of acetic anhydride in the presence of organic carboxylic acid salts of Mn or Co as the catalyst and oxygen under a partial pressure above 50 psi. The reaction is stopped while at least half of the alkyl benzene remains unoxidized. Non-acidic mixed-aromatic-aliphatic oxidation products, such as mixtures of acetophenone and phenyl methyl carbinol are obtained.

U.S.P. 2,546,639-40. Production of Phenol by Oxidation of Benzene. G. G. Joris to Allied Chemical & Dye Corporation.

Benzene, oxygen and a certain amount of open chain hydrocarbons having an unbranched saturated chain of at least 3 C atoms and/or of cyclic saturated hydrocarbons with at least 6 C atoms are introduced into a reaction zone maintained in its hottest part at a temperature of 250-400° C. Phenol is produced. Instead of the said hydrocarbon promoters a di-n-alkyl ether containing 2-8 C atoms can be employed.

U.S.P. 2,547,138. Chlorination of Hydrocarbons. M. Randall, Berkeley, California.

Chlorine, an unsaturated aliphatic hydrocarbon with 2-6 C atoms, and a catalyzing amount of anhydrous $FeCl_3$ sufficient to maintain the system anhydrous are separately introduced into a reaction zone maintained at reaction temperature. A portion of the liquid product is externally cooled and returned to the reaction zone to remove the heat of reaction. Additional products of the unsaturated hydrocarbons and chlorine are produced.

U.S.P. 2,547,766. Vapor Phase Hydration. J. H. McAteer to Standard Oil Development Company.

Olefin vapors and water vapor are contacted in a reaction zone free of liquid in the presence of a solid metal fluoride catalyst, particularly such a catalyst of gel structure, e.g., AlF_3. Hydration products are formed.

U.S.P. 2,547,905. 2-Vinylthiophene from Thiophene by Chloroethylation and Dehydrohalogenation. W. S. Emerson and T. M. Patrick, Jr., to Monsanto Chemical Company.

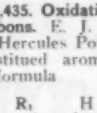
Thiophene and acetaldehyde are reacted in the presence of an excess of hydrogen halide. An approximately stoichiometric proportion of a tertiary amine, such as pyridine, is added. The 2-vinylthiophene formed is separated by distillation in the presence of an olefinic polymerization inhibitor.

U.S.P. 2,547,938. Manufacture of Alkyl Benzene Peroxides. R. H. Hall and D. C. Quin to Hercules Powder Company.

An alkyl benzene containing an alkyl substituent with a tertiary C atom in alpho-position to the benzene ring is oxidized in dispersion in a liquid aqueous continuous phase at a pH of 7-11 by the action of molecular oxygen under increased pressure at elevated temperature. The corresponding alkyl benzene peroxide is formed.

U.S.P. 2,548,435. Oxidation of Aromatic Hydrocarbons. E. J. Lorand, J. E. Reese to Hercules Powder Company.

Alkyl-substituted aromatic hydrocarbon of the formula



in which R_1 and R_2 are alkyl groups and A_r is an aryl or alkaryl group, e.g. p-cymene, cumene, or diisopropylben-

PETROLEUM CHEMICALS DIVISION
NEWS

June ★ One of a Series of Interest to the Petroleum Industry ★ 1951

DU PONT COMPLETES NEW PETROLEUM LABORATORY FACILITIES

J. J. Mikita Appointed Director of Du Pont Petroleum Laboratory

February 1, 1951 marked the beginning of J. J. Mikita's second term as director of the Du Pont Petroleum Laboratory. He previously held the post from September 1946, when he first joined the Company, until October 1949.

Since then he has served as assistant technical manager at the Wilmington Office. His return to the laboratory was prompted by the expanding activity of petroleum chemicals research being carried on at the new quarters.

Mr. Mikita was graduated from Penn State College and received his Masters Degree in mechanical engineering there in 1933. He continued at Penn State as a research assistant until 1936, when he joined the Texas Company as an engineer. There he became associate director of research before joining Du Pont in 1946.

Buildings House Main Research Activity of Expanding Du Pont Petroleum Laboratory

To accommodate the rapid expansion of Du Pont's petroleum research work, major additions to the Petroleum Laboratory set-up have recently been completed at the Chambers Works in Deepwater, N. J. These additions consist of several structures, designed especially for petroleum research.

Main laboratory building has a monitor top which houses fuel, air, water and electric lines. Administrative offices, conference and reception rooms are located in two-story front section. Remainder of building is devoted to engine testing compartments and general service equipment.

In addition to the main building, which houses the offices and test engine rooms, there is a complete fuel blending unit and tank farm. Also an enlarged garage with maintenance facilities for the road-test fleet. Construction was started in August 1949 and today all units are equipped to operate at full capacity.

Activity ranges all the way from basic research on combustion problems to development of additives for jet fuels. It includes the design and construction of special test engines and instrumentation on road-test automobiles.

FUNCTIONAL DESIGN

The main building was developed with an eye to comfort and efficiency as well as to the safe handling of fuels and exhaust gases. Twenty-six stands for mounting test engines are distributed through eight rooms. On them, engines ranging from small single-cylinder test engines to the largest truck diesels can be operated.

Many of the stands are equipped with dynamometers for absorbing and measuring engine power. They carry extensive instrumentation. For added safety and comfort, the operating controls and instruments are mounted on panel boards at a distance from the engines – frequently outside the engine room.

In addition to complete engine testing facilities, the main building contains air-conditioned offices and con-

CONTINUED ON PAGE 3

Laboratory Conferences Coordinate Research

Close cooperation by the laboratory staff is an important factor in Du Pont petroleum research. Here Mr. Mikita is discussing test results with the engineering group. Meetings like this speed up laboratory operations as well as plans development. They also give each engineer an opportunity to contribute to the various projects.

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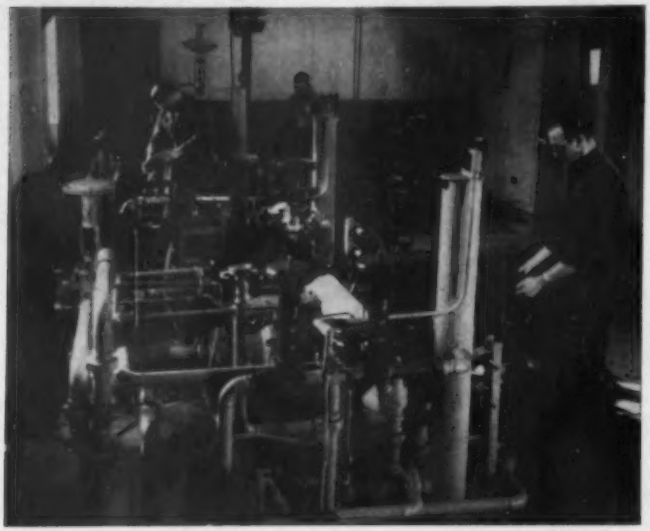
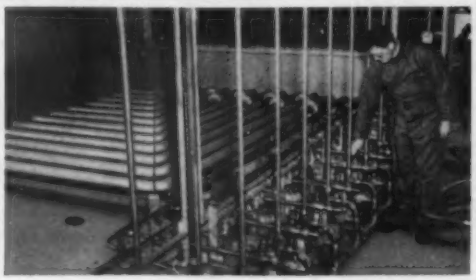


Today's Engines Help Develop Tomorrow's Fuels

Stock engines representing standard car makes are used for research on fuel performance at the Du Pont Petroleum Laboratory. Mounted on stands in this multi-cylinder engine testing room, they are connected with dynamometers and other testing devices. Special instrumentation—on panels outside the room—records the performance of each engine. The results of these tests are the bases for findings that lead to improved fuels and lubricants and better engine performance. There are two multi-cylinder engine rooms in the new laboratory—additional rooms in the old buildings.

Complete Storage and Blending Facilities

THE NEW TANK FARM has a storage capacity of more than 60,000 gallons. Each of its 12 tanks can be used for storing a different fuel. Located a safe distance from the main building, the farm is connected to the fuel transfer and blending building by a system of pipelines which permits complete blending flexibility.



THIS ORDERLY ARRANGEMENT of pipelines and blending pumps in the transfer and blending building simplifies blending operations. To assure safety and accuracy, each pipe is clearly identified.

Safety and Comfort Featured in New Du Pont Laboratory Buildings

Fuel lines . . . exhaust gases . . . electric wiring . . . high pressure air lines! Put them all together, and they can spell trouble—unless careful handling keeps them functioning safely. Special attention was paid to the design of the laboratory buildings so as to virtually eliminate danger and trouble from any of these sources.

To isolate these services, an enclosed area running the length of the laboratory was built on the roof. Fuels and electrical services are routed to the engine room through concealed ducts. Engine exhaust, coolant and spilled liquids are collected in a sealed trench which passes under the floor. Special pumping equipment keeps them moving out to safe disposal facilities. A complete change of air in each engine room is provided every 3 to 5 minutes.

Built-in ventilation control and fire protection, important features of the laboratory design, are frequently checked to assure safe operation.

Many control panels are located in this corridor—outside of the engine rooms. Test stands are equipped with an automatic device to stop the engine if unsafe conditions develop.

As a double check, a warning is flashed by this clearly visible panel should anything go wrong with the ventilating system or other protective equipment.

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PETROLEUM CHEMICALS DIVISION
NEWS

An Engine Writes Its Own Story!

On this control panel are dials and instruments to register all significant details of an engine's performance. Variations in the performance of fuels can be accurately charted. The engine itself can be observed by the operator through the recessed window in the center of the panel.

An indicator chart tells this laboratory technician the pressure being generated in the combustion chamber of a single-cylinder engine. Through recording instruments, the engine actually writes its own story.

Du Pont Designs and Builds Special Instruments for Petroleum Research

ELECTRONIC INSTRUMENTS for engine testing are developed and assembled in this laboratory workshop. This work includes some of the special instrumentation and apparatus built into the test fleet cars, as well as the intricate control panels for laboratory test engines. The Petroleum Laboratory also has its own machine shop and engine overhaul room.

BASE OF OPERATIONS FOR DU PONT TEST FLEET

This brick structure, near the new laboratory building, is the garage headquarters for the Du Pont east coast passenger car test fleet. Many standard makes are represented in the 28-car fleet. Equipped with special instrumentation, the cars are essentially on-the-road research laboratories.

Complete servicing and overhaul facilities are installed in the garage. Special equipment keeps testing devices of the cars tuned to a high degree of accuracy.

CONTINUED

New Lab Facilities

ference rooms for laboratory personnel. It also houses the many auxiliary services needed for operating the laboratory . . . plus a lunchroom for those who do not make use of the plant cafeterias.

COMPLETE SERVICE FACILITIES

To keep research work progressing satisfactorily many extra services are needed. For convenience and efficiency, provisions for these are built into the main laboratory wherever possible. There is an overhaul shop for rebuilding engines and a machine tool room for turning out special engine parts. For routing 18 fuels from the blending building to any of the 26 test engines there is a special piping system which supplies the necessary flexibility for experimental work.

From the compressor room comes dry and oil-free air for supercharged engines, as well as air and vacuum service for various instruments. The laboratory has its own electronic shop where new instruments are developed and repairs are made.

OVER

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PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED

New Lab Facilities

SIMULATES REFINERY

The blending building and tank farm are similar to those found in refineries. Twelve storage tanks give the tank farm a capacity of more than 60,000 gallons. Racks provide additional storage for 360 fifty-five gallon drums.

In the blender building, tetraethyl lead and other additives can be readily blended with any combination of fuels from the main tanks. These fuels can be dispensed directly to test-car refueling pumps or to the laboratory fuel distribution room.

WORK IN PROGRESS

An enlarged research program is already under way in the new facilities. It includes work on fuel storage stabilizers and additives for making lube oils more suitable for modern high-speed engines. Studies of basic combustion problems have been expanded and are aimed at discovering new methods of suppressing knock.

PIONEER

Dr. W. S. Calcott Directed Early Research on TEL

In 1922 the Du Pont Company accepted a challenge to manufacture tetraethyl lead safely. The intensive study and exhaustive experimental work that followed was under the able leadership of Dr. W. S. Calcott of the Du Pont Jackson Laboratory.

As a result of this work, Du Pont was successful in perfecting a process for producing tetraethyl lead which contributed important features toward maintaining the excellent safety record subsequently established in the manufacture of this product. The basic techniques developed by Dr. Calcott and his associates are still in use today.

Continuous Tests Show Way to Product Improvements

Tested in use, in storage, in idling engines, and in combination with other fuels or lubricants—every Du Pont additive must pass a comprehensive schedule of tests before it is made available to the industry.

Constant evaluation of product characteristics sometimes leads the way to the development of new and better products—another important contribution of Du Pont research.

Exploring basic combustion chamber reactions is a continuing job at the Petroleum Laboratory. It is helping to pave the way for future improvements in fuel antiknock additives. Problems are first studied in the laboratory and then taken out on the road where they can be studied under varying driving conditions. Seven of the laboratory's 28 cars are specially equipped to do this work.

Chemical analysis of fuel components and reactions is among the steps constantly employed in the development of petroleum additives.

In connection with gasoline, Du Pont research contributed to an effective metal deactivator as well as several antioxidants for increasing stability.

How Du Pont Research Aids Petroleum Refiners

To help refiners in the economical and efficient use of current additives is one of the primary aims of Du Pont petroleum chemicals research. Another is the development of new fuels and lubricants. To accomplish these things, the program is unusually broad.

It includes the work of test fleets—both passenger cars and heavy-duty trucks—as well as laboratory studies.

For on-the-spot assistance, five conveniently located field laboratories are prepared to conduct special investigations on your own fuels, as well as help with treating and blending problems.

In addition, many of the findings of Du Pont's vast company-wide research program have valuable application in the petroleum industry. Neoprene, explosives and finishes are outstanding examples.

Refinery research groups find it helpful to attack their problems in joint meetings with Du Pont petroleum specialists.

LITERATURE AVAILABLE

The following is a partial listing of free Du Pont bulletins, reports, booklets and aids available to you. Address request to your nearest Du Pont Petroleum Chemicals Division District Office.

Working with the Petroleum Industry—information about Du Pont's TEL manufacturing and research facilities ..... Serial A-8620

Tank Talk—a 52-page, pocket-sized booklet written for the men who actually enter and clean gasoline storage tanks ..... Serial A-1134

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zene, are oxydized by passing an oxygen-containing gas through the liquid hydrocarbon at a temperature of 20-95° C. in the presence of liquid water or an aqueous alkali.

U.S.P. 2,548,585. Alkylation of Urea with Olefins. H. C. Brown to Standard Oil Company (Indiana).

Urea and N-monoalkyl ureas are alkylated by contacting at least 2 mols of a tertiary olefin, such as isobutylene, with one molecule of the urea compound mixed with H_2SO_4 of a certain proportion and strength at a temperature of —20° to +25° C. N-t-alkyl urea and N, N'-di-t-alkyl urea compounds are obtained.

U.S.P. 2,548,764. Chlorination of Hydrocarbons. G. W. Ayers and E. E. Harton, Jr., to The Pure Oil Company.

Saturated hydrocarbons having a tertiary C atom are contacted with a chlorinating agent in the presence of nitrosyl chloride or metal nitrates or nitrites, excepting uranium salts, capable of reacting with chlorine under reaction conditions to form nitrosyl chloride. Saturated hydrocarbons present which do not have a tertiary C atom are not chlorinated by the claimed process.

Fluor Promotes Three Engineers at LA Plant

Recent promotions at the Fluor Corporation, Ltd., Los Angeles, have resulted in new titles for three men located at the home plant. Robert L. Merrick, former manager of engineering, has been appointed manager of engineering and construction; John Marshall becomes manager of engineering, and Frank G. Crawford assumes the duties of chief engineer-mechanical.

Merrick is a graduate of the Armour Institute of Technology, Chicago. Marshall is a native of Illinois and got his degree from the Colorado School of Mines. Crawford, who comes from Pasadena, Calif., holds a degree from the California Institute of Technology. He is at present project manager for the Atomic Energy Commission's plant being built by Fluor at Arco, Idaho.

Honolulu Oil Elects Pair

W. H. Kraft and F. M. Cole have been elected vice presidents of the Honolulu Oil Corporation. Kraft also appointed to board of directors, was employed by Honolulu Oil Corporation in 1925 and has been in charge of all gas and gasoline operations of the company throughout California and the Mid-Continent for ten years. Cole was employed by the company in 1937 and has been assistant to the executive vice president since 1947.

Spahr and Moller Promoted

A new vice president of The Standard Oil Company (Ohio), Charles E. Spahr, will continue his duties as manager of the transportation department. Spahr has been with Sohio since 1939.

Another appointment recently made was that of Hans S. Moller, Jr., who was promoted from the secretary's office for stockholder relations to assistant secretary of the company.

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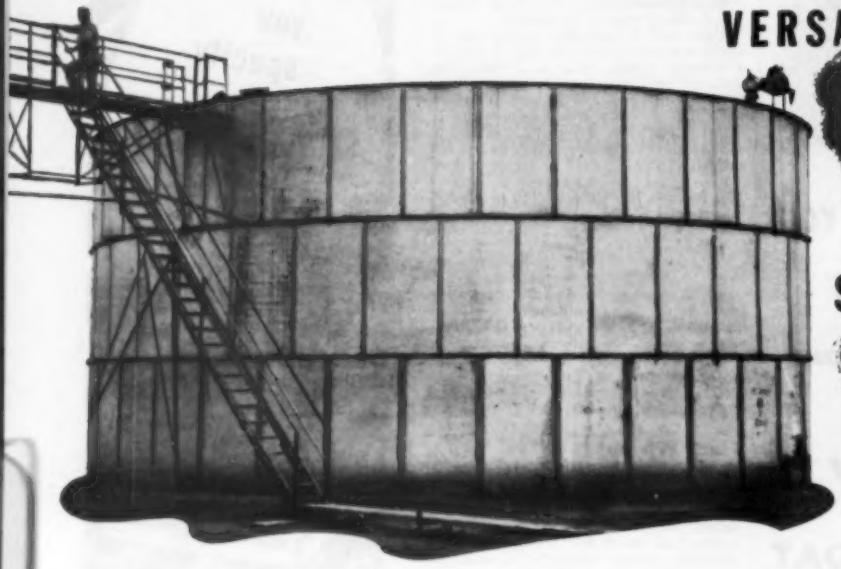

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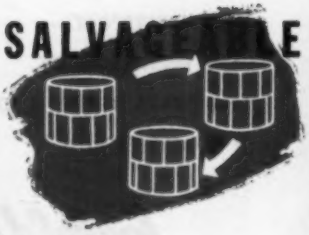
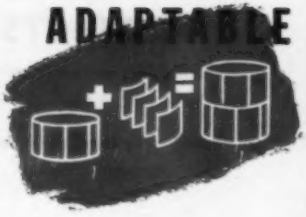


ADAPTABLE



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Japan and Fuel Synthesis

Information Circular 7594, The Synthesis of Hydrocarbons (Report of the Imperial Fuel Research Institute of Japan), Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13. Free.

This publication reveals that Japan, unlike Germany, never succeeded in obtaining a substantial part of its oil supply from coal and in fact based their research on theories which have been discarded on experimental evidence. In any event, Western scientists and technologists have available detailed data on the research for production of synthetic liquid fuels from coal by the Fischer-Tropsch process as carried on by the Imperial Fuel Research Institute of Japan between 1932 and 1935. This process provided 149,250 of the 1,055,000 barrels of synthetic liquid fuel produced in Japan in 1944, the year of peak production. In that year, the Japanese also produced 5780 barrels by direct hydrogenation of coal, and 899,970 by low-temperature carbonization.

The report is cross-indexed with research results arrived at in Germany, Britain, the United States and France, during that period.

Organic Chemistry

Chemistry of Organic Compounds, Carl R. Noller, W. B. Saunders Company, West Washington Square, Philadelphia 7. $7.00.

This chemistry text emphasizes only the physical properties, methods of preparation, nomenclature, chemical reactions, and uses of organic compounds. Written at the basic level, it is designed to allow the better student opportunity to acquire as much knowledge as he is able to assimilate. The theory of gross structure which correlates the reactions and physical properties of organic molecules with the kinds of atoms present and with the order in which the atoms are bonded to each other in the molecule is the basic theme of presentation. Although knowledge of the constitution of molecules is basic to laboratory synthesis of countless new compounds, many of which have practical use, text books have paid little attention to the mechanisms of reactions. To enable the non-mathematical mind to grasp the physical picture of the phenomenon of resonance, both the atomic orbital treatment developed by Heitler and London, Pauling and others since 1927, and the molecular orbital treatment developed since 1928 by Hund, Milliken and others is developed.

The book is printed in standard size type, with small type used for supplementary material only.

Routine Analysis Methods

The Bureau of Mines Routine Method for the Analysis of Crude Petroleum, I, The Analytical Method, Bureau of Mines Bulletin 490, Superintendent of Documents, U.S. Government Printing Office, Washington 25. 50 cents.

This new bulletin, a revision of Bulletin 207, describes the equipment and procedures used in the routine method of making crude oil analyses; discusses distillation, sampling and sample handling, determinations of properties, and preparing the report of an analysis, including an outline showing the procedure to be followed.

The appendix includes a bibliography of reports and a list of published analyses of crude oils arranged by States and fields in alphabetical order, with reference to the publications. Inexperienced analysists are given special help by the Bureau authors who point out common errors made in distilling crude oils and determining some of their properties.

Plant Maintenance

Techniques of Plant Maintenance—1951, Clapp & Poliak, Inc., 341 Madison Avenue, New York 17. $6 per copy.

Recent developments in problems of plant maintenance are discussed by the management which staged the Plant Maintenance Show held in Cleveland last January. Companion piece to "Techniques of Plant Maintenance—1950," a mimeographed booklet, it contains the proceedings of the Plant Maintenance Conference held in conjunction with the show. This year's edition is printed and bound.

One feature is a question and answer section submitted after each of the twelve sessions. Subjects are discussed by 40 nationally known experts and cover such things as preventive maintenance, inspection procedures and frequencies, records and reports, training personnel for maintenance, organization and management for maintenance, maintenance costs, incentive payment of maintenance workers, planning and scheduling maintenance operations, and many others.

Advanced Chemistry

Organic Chemistry, Frank C. Whitmore. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3. $12 per copy.

In line with the trend toward alinhatic chemistry, especially in British and American industry, nearly three-fourths of this volume is devoted to aliphatic and alicyclic chemistry. Aromatic chemistry is dealt with rather briefly, while heterocyclic compounds are relatively stressed. The complex alkaloids are presented in an orderly arrangement based on an analysis and classification of possible combinations of nitrogen-ring systems. Written for the practicing chemist and the advanced student, the author candidly advises that the condensation necessary will force the user to expand many of the formulas and equations.

Chemical Service Reference

Consulting Services 1951, Association of Consulting Chemists and Chemical Engineers, Inc., 50 East 41st Street, New York 17. Free if you mention this magazine, and the name of your company.

Book is divided into three main sections, Classifier, Scope Pages, and Index. The Classifier sections contains approximately 100 headings and lists pertinent key numbers after names of members specializing or qualifying in the field indicated by the key. Also carries excerpts of the Code of Ethics and the By-Laws.

German Technology Reviewed

The Fischer-Tropsch and Related Syntheses, Henry H. Storch, Norma Golumbic, Robert B. Anderson, John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16. $9.

This book is a detailed summary, documented and critically analyzed, of the information uncovered by American and British teams of chemists and engineers since the Allied advance into Germany in 1945. As German documents were inspected and German technologists interrogated, a large amount of scientific and engineering data were collected. Much of this data pertained to research and development work related to fuels and chemical synthesis. The development of the Fischer-Tropsch process, the synthesis of aliphatic organic compounds, chiefly hydrocarbons and alcohols, by the catalytic hydrogenation of carbon monoxide, is critically reviewed. Included is a review of fundamental and applied catalysis and an introduction to the "oxo" and isoparaffin synthesis. This study was amassed in entirety from actual plant processes and documents which generally would be unavailable.

Facts and Figures

Petroleum Facts and Figures, American Petroleum Institute, Department of Information, 50 West 50th Street, New York 20. $2.50 per copy.

First edition since 1947, this volume is reputed to be one of the oil industry's most authoritative compendiums on vital petroleum statistics. The large new edition contains historical data reaching back to the early days of oil, and the API claims it is so complete that reference volumes for early statistics or other data, are not necessary. In addition to long-term series of tables on utilization, production, refining, marketing, transportation, prices and taxation, the ninth edition contains a new series of tables on business, operating and allied statistics. Supplements for the 1951 edition will be issued annually for five years.

Arc Welding Elements

New Lessons in Arc Welding, The Lincoln Electric Company, Cleveland, Ohio. $1 per copy; $1.50 outside continental U.S.A.

The 320-page book is based on lessons and instructions given at the Lincoln Arc Welding School, lessons which stress practicality and not theory. Basic fundamentals of arc welding as well as more advanced welding in alloys, sheet metal and pipe is given what seems to be rather complete coverage. The basic 32 lessons cover welding mild steel in all positions and 29 advanced lessons cover other welding applications. Practice materials, exercises, questions and answers are suggested for each lesson.

Practical lessons encompass latest welding procedures for faster and lowest cost welding; automatic and semi-automatic

Books

hidden arc welding procedures; how metals are made and how to identify them; how to select correct welding joints; how to make common machine parts of welding instead of casting.

Protection for Industry

Plant Protection for National Defense, Detex Watchclock Corporation, 76 Varick Street, New York 13. Free

Revised version of a manual which watchmen, guards, supervising personnel and management found instructive as a guide during World War II, it has been modernized and now includes atomic warfare precautions and organization. It is designed to solve plant protection problems by instituting security systems for preventing loss of life, damage to property and sabotage of war materials. Training of watching personnel, the planning of hourly routes and other important data for forestalling enemy agents, are contained in the booklet. Copies are available for any manufacturer engaged in, or likely to get government orders.

Sols and Gels Discussed

Viscosity and Plasticity, E. N. Da C. Andrade, Chemical Publishing Company, Inc., 212 Fifth Avenue, New York 10. $2.25 per copy.

Outlined are three lectures on the phenomena of viscosity and plasticity. The subject matter is slanted to those who deal with viscous and plastic materials on an industrial scale, especially to paint technologists. The nature and theory of liquid viscosity is discussed with a view to establishing general principles in order to derive from these an understanding of the very complex behavior of flowing liquids and solids. Sure knowledge of physical principles could help manufacturing engineers and chemists to improve their products and to expand the field of application of viscous liquids.

The second lecture deals with the flow simple liquids, suspensions and gels, considers thixoiropy, dilatancy and other properties affecting flow. The flow of solids is the topic of the third lecture, and covers discussion of sols and gels which can be poured slowly or with difficulty. Contains 32 illustrations and figures.

Gas Explosion Prevention

Gas Explosions and Their Prevention, Circular 7601, G. S. Scott, R. E. Kennedy, and M. G. Zabetakis, Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13. Free.

Prepared primarily for the use of engineers and chemists with limited technical knowledge of gas explosions, the circular explains the limits of flammability of various gases and vapors, i.e., the range of composition within which a mixture of gas and air is explosive. Formulae for determining the flammable limits of mixtures of flammable gases are presented as well as methods of preventing gas and vapor explosions.

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Shell Is Recognized for Marshall Plan Cooperation

On the third anniversary of the Marshall Plan Shell Chemical Corporation was awarded a Marshall Plan Certificate of Cooperation by New York's Mayor Vincent R. Impellitteri.

The certificate presented on behalf of Economic Cooperation Administrator William C. Foster, was awarded in recognition of assistance rendered by Shell Chemical to teams of visiting foreign experts brought to the U. S.

Indoil Executive Elected

M. H. Arveson of Chicago, technical director of the Indoil Chemical Company, has been elected a director-at-large of the American Chemical Society to fill the unexpired term of Dr. Edgar C. Britton of the Dow Chemical Company, who was recently elected president of the society.

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For small, individual orders of reprints of its articles PETROLEUM REFINER makes a charge of 50 cents per copy WHEN REPRINTS ARE AVAILABLE.

The charge for tear sheets of a particular article when available is 25 cents.

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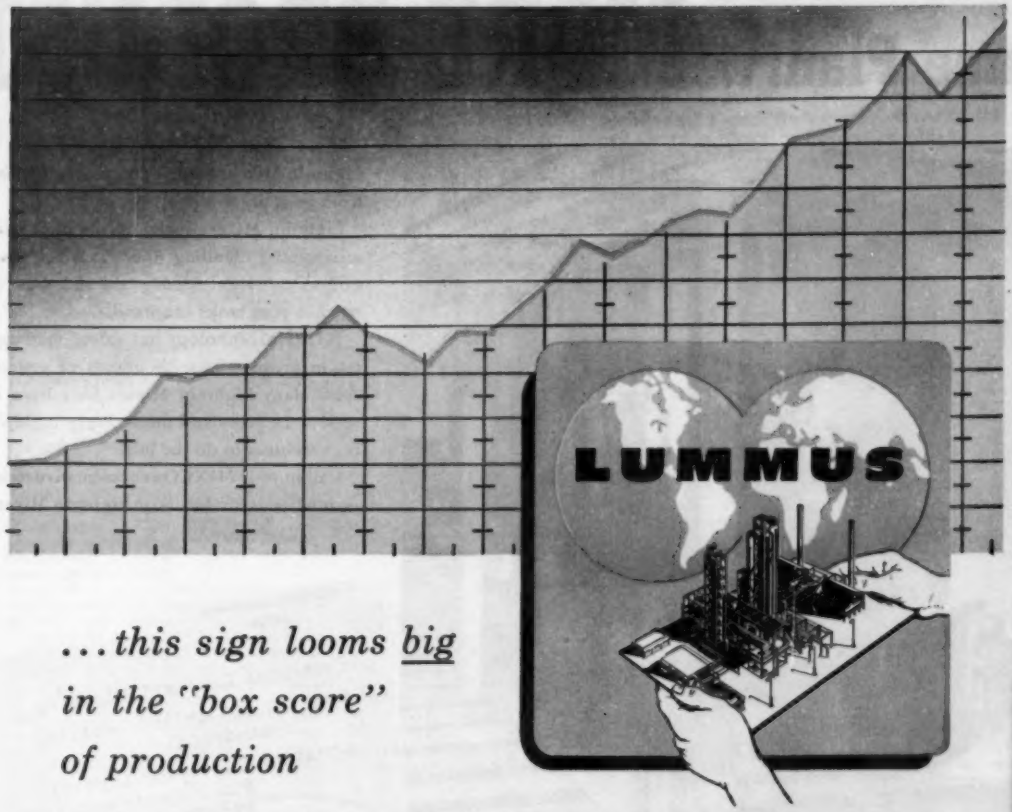

...this sign looms big in the "box score" of production

For better than sixty years the Lummus sign has meant *excellence* in the designing, engineering and constructing of petroleum refineries and chemical plants. It means the same today. And you need take only a short mental jump to see its importance in the days ahead, as oil refiners and chemical producers are called upon to break and re-break production records.

Let's look at a partial "box score" of Lummus' current contributions toward these world-wide objectives. In the U. S. and abroad, Lummus is engaged in seven catalytic cracking projects—as well as in providing alkylation facilities—to meet the record-breaking demand for superior aviation and motor fuels.

Lummus currently has seven ethylene units "on the go" in Europe and the U. S.—plants which will operate with telling effect in supplying a vital basic raw material. One project—the Gulf Oil Corporation unit at Port Arthur, Texas—is the world's largest ethylene unit. It will produce nearly 2½ billion cubic feet yearly, increasing total U. S. production of ethylene by about 12%.

Isn't this a reassuring record for you to tie to? It strongly suggests that you think of Lummus first in your plans for petroleum refinery or chemical plant expansion.

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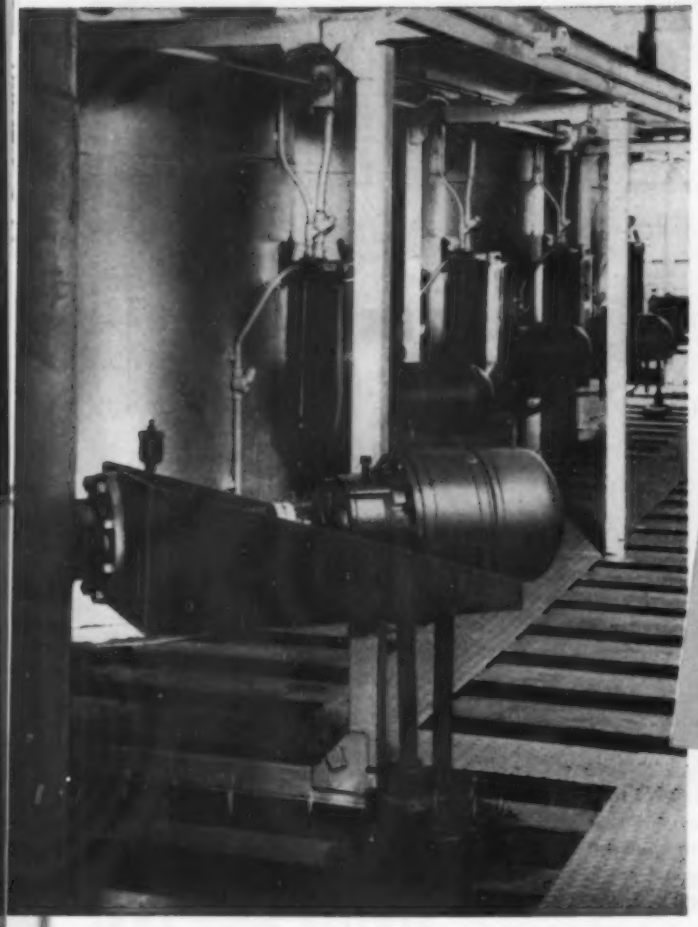

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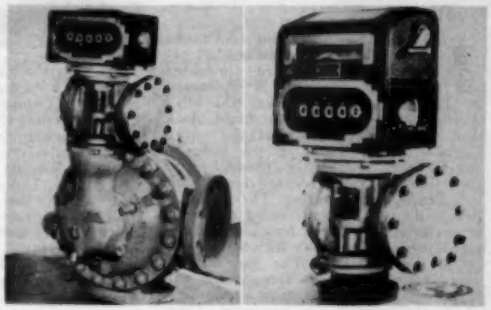
NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information about products described on these pages use the coupon below, circling the number shown for each item desired. Or write the manufacturer direct to address as shown.

Gas Audit Meter

1 A remote registration system for metering petroleum products at one point while recording the volume metered and printing receipt records in a station at some distance from the meter, has been developed by Rockwell Manufacturing Company, 400 North Lexington Avenue, Pittsburgh 8. The unit consists of a transmitter on the meter and a receiver in the office, or wherever metering readings are recorded. Both transmitter and receiver are equipped with electrical synchronous type motors, mounted in explosion proof Underwriters' approved housings. Each is equipped with a register, the one on the receiver usually being of the printing type which records receipts of all loading operations. These records provide for basic liquid auditing. As the product is measured the transmitter is rotated through a gear drive in proportion to meter revolutions. When field circuits are energized, rotation of the transmitter is exactly duplicated by the receiver in the control office. On left is closeup of transmitter registration unit and on right is a receiver unit, the latter equipped with printing register. Bulletin Number O.G. 324.



Torque Wrenches

2 A new series of torque wrenches for three-eighths, one-half and three-quarter inch square drives is made by Bonney Forge & Tool Works, Allentown, Penn. The new torque wrenches feature a broad, pretested tension bar, and because of their long, thin design, provide easy access to tight spots. Handles are pivot-mounted to maintain a constant leverage radius. Easily read calibration scale is available in foot-pound or inch-pound calibrations as desired. The torque wrench series is available at all Bonney distributors.

Steam Detergent Cleaning

3 Steam-detergent cleaning for industrial maintenance operations is the subject of a folder published by Oakite Products, Inc., 150B Thames Street, New York 6. The folder defines steam cleaning as the simultaneous application of three actions; physical action of steam pressure and hot water working through the grease and dirt; the dissolving action of heat on oils, greases and other deposits; and the chemical action of the detergent in penetrating, wetting and emulsifying surface deposits. Industrial set-ups where this type of cleaning is especially time-saving are described. Specifications of steam cleaning equipment is included.

Rubber Drums and Barrels

4 United States Rubber Company, Rockefeller Center, New York 20, has developed a new 55-gallon synthetic rubber-fabric drum, suitable for shipping liquids, collapsible after emptying, returnable and reuseable. Made of Ustex cord fabric and impregnated with synthetic rubber molded in one piece, the drum is said to be tough, flexible, approximately the size of a regular barrel. Collapsed, 2500 of these barrels can be shipped in a standard railroad box car that would hold only 300 rigid drums. The material is non-corrosive, non-absorbent and highly resistant to weathering. They are currently manufactured in limited quantities for essential uses in the petroleum and liquid chemicals industries.

Pumps

5 A redesigned line of two-stage pumps, designed as "Type DMD" in sizes from 2 to 10-inch discharge with capacities up to 4000 gpm. and heads to 750 feet, is announced by Economy Pumps, Inc., Hamilton, Ohio. The single DMD pump of the two-stage design is said to produce as much head as two single stage pumps piped in series. New standard Economy DMD pumps are recommended by manufac-

FOR ADDITIONAL INFORMATION on products and literature mentioned in this section write the manufacturer direct or circle item numbers, cut out and mail this coupon. Prompt action is suggested so that data will be forthcoming without delay.

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New Equipment

(For additional information or literature check item numbers on mailing coupon, page 211, or write manufacturer direct.)

turer for service in oil refineries, chemical plants, and allied uses. Feature of pump is a horizontally split casing with interconnecting passage between the two opposed impellers of the non-overloading type, hydraulically and dynamically balanced at the factory. Bulletin.

Valve Seat Grinder

6 A new portable valve seat grinder, especially designed for large internal combustion engines with inside seat diameters from 2-5/16 to 12 inches has been developed by Thompson Products, Inc., 8354 Wilcox Avenue, Bell, Calif. The unit can be used for grinding both valve seat faces and counterbores within the size range, and regularly holds concentricity to .003 inches. May be used wherever air pressure is available. Consists essentially of grinding unit with easily accessible controls, a wheel dressing unit and an air motor drive. It is driven at 10 rpm. around a pilot centered in the valve guide, with the grinding wheel operating at 12,000 rpm. Grinding unit housing and wheel dressing unit are of cast iron to absorb vibration.

Heat Transfer Units

7 A new standard line of electrically heated Dowtherm heat transfer units is offered by Struthers Wells Corporation, Warren, Penn. Supplied complete with instruments, piping, insulation and other accessories, these units are ready for immediate use upon delivery. Capacities range from 100,000 to 500,000 Btu.'s per hour, and temperatures range to about 750° F. using Dowtherm as a liquid or vapor medium. Other heat transfer fluids can be utilized in this equipment. The entire unit can be base mounted at the factory or shipped for individual mounting. The heat transfer units include a special heating element, designed to eliminate thermal breakdown or coking troubles. Bulletin B-45.

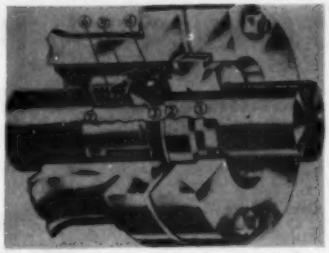
Floating Roof

8 Three types of floating roof tanks for product conservation and corrosion resistance are illustrated and detailed in Bulletin 51 F, issued by Hammond Iron Works, 630 Fifth Avenue, New York 20. The double deck roof provides insulation of the entire surface of the liquid in the tank to substantially reduce the possibility of corrosion and product losses due to boiling, breathing and filling. The pontoon-design floating roof utilizes a minimum of material to achieve buoyancy and is recommended for tanks with a diameter of 50 feet or more. The pan floating roof is used in areas free of ice and snow conditions. It is most economical of the three for storing products of low volatility.

Steam Turbine

9 A concise booklet describing the vertical drive steam turbine and giving pertinent technical data has been issued by Whiton Machine Company, New London, Conn. This type drive is built in three general sizes 14 inch rotor BTV, 24 inch rotor BKV and 36 inch rotor BEV. It handles industrial applications up to 600 hp. with thrust loads of 8000 pounds or more; and steam conditions as high as 900 psig; with 900° F. total temperature. Facts pertaining to the application of the vertical turbine to refineries, etc., are reviewed.

Mechanical Seal



10 "Type 9 Mechanical Shaft Seal" has been designed by Crane Packing Company, Dept. P-23, 1800 Cuyler Avenue, Chicago 13, for effective performance under severe temperature and corrosive conditions. Type 9 incorporates a flexible ring molded from the new plastic, Teflon. The Teflon "wedge-ring" enables this seal to combine chemically-inert properties of Teflon with the flexibility and positive sealing components essential to effective mechanical sealing. Can be used under temperatures up to 500° F. Construction of the seal is shown in the cut-away drawing: The set-screwed metal retainer (7) provides a positive drive from shaft to carbon sealing washer (2) through dents (4) which fit into washer notches. An effective seal between the shaft and washer is insured by the precision machined Teflon wedge ring (3) which is preloaded by the action of multiple springs (6). Spring pressure is uniformly distributed by a metal disc (5). The lapped raised face of the rotating sealing washer (2) mates against the highly lapped face of the stationary seat (1) to provide a positive leakproof seal with minimum running friction between the vertical faces. Spring pressure keeps the faces in constant contact providing automatic adjustment for wear and shaft end play. Booklet.

Fin Tubes

11 Heat-X longitudinal fin tube, manufactured by Heat-X-Changer Company, Brewster, N. Y., is designed for a high rate of heat transfer of liquids and gases, and provides the advantage of maximum heat transfer with minimum pressure drop. Available with one or two finned annular spaces with outer tubes ranging from 5/8 to 2 1/8 inches and inner tubes 1/4 to 3/4 inches. Standard tubes are of copper with copper or aluminum fins. Other materials obtainable on special order. The tubes are available in finned lengths up to ten feet in six-inch increments. Said to be a space saving, efficient unit.

Gauge Valve

12 Edward Valves, Inc., Rockwell Manufacturing Company, East Chicago, Ind., offer an additional design of male inlet and female outlet in Edward forged steel gauge valve series in the popular half-inch size. The new gauge requires no nipples, as that usually necessary when hooking up pressure gauges to pressure tubing or casing, because the male inlet basically serves the same purpose as a nipple. The male inlet is an integral part of the forged steel valve body thus offering greater strength and soundness. The wall thickness of the male inlet is extra heavy for high pressures and pro-

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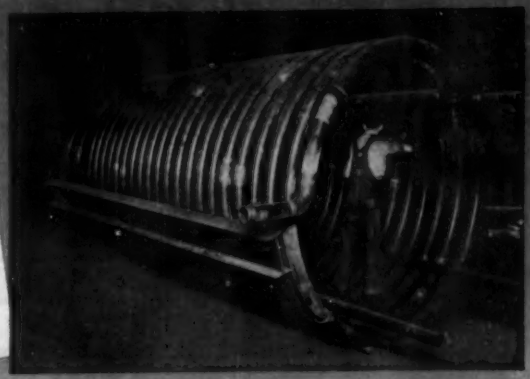
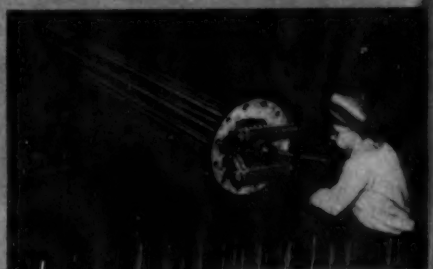
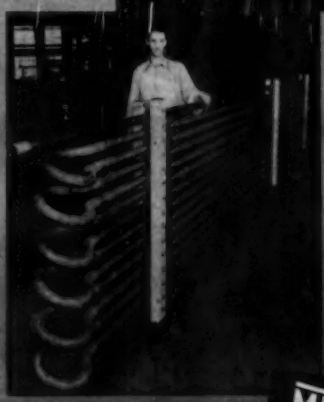


Cylindrical coil of polymerization heater coil approximately 8 ft in diameter and containing 850 ft of 4" standard Grade "A" seamless steel pipe.

A nest of box coils containing 850 ft of 2" extra strong seamless pipe, to be used as storage tank heater.

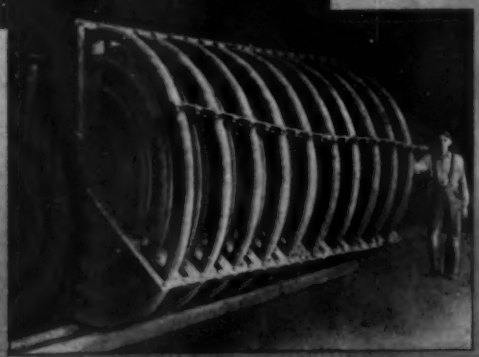
Catalytic reactor coil containing of 20 flat spirals of 4½" OD x ½" wall 4-6% chrome, ½% moly seamless pipe. Full-furnace annealing distorted temporary shipping straps.





Heated hairpin coil used as unit heater in 14' diam tank; made from 300 ft of ¾" OD x #14 BWG seamless boiler tubing.

Condenser coil fabricated from 2" OD x ⅝" wall seamless steel pipe. Coil was tested to 7500 psi and is 26 ft long.



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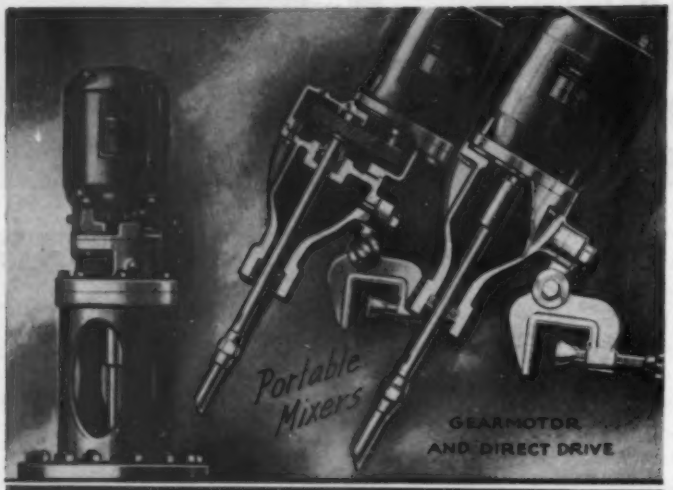

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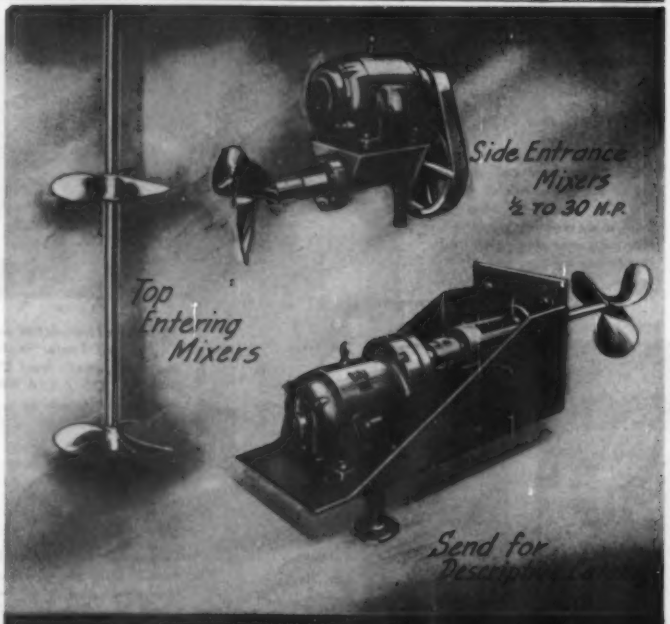


International
ENGINEERING, INC.
NEW YORK
15 PARK ROW
DAYTON, OHIO
CHICAGO
407 S. Dearborn
DISTRICT REPRESENTATIVES IN PRINCIPAL CITIES

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 211, or write manufacturer direct.)

vides greater protection against breaking off or rupturing. It features a safety taper threaded joint between the body and bonnet to prevent the bonnet from backing out of the valve due to vibrations. Catalog sheet 510.

Rust-Inhibitor

13 A new oil-soluble rust inhibitor, L-1673, protects metals from corrosion 10 to 15 times longer than previous formulations according to Alox Corporation, 3915 Buffalo Avenue, Niagara Falls, N. Y. The main advantage of the new formula is that it is not easily removed because polar compounds contained in ALOX-L-1673 adhere tenaciously to metal surfaces, bonding the oil to the surface to form a dense barrier to corrosion by moisture, salt water, and corrosive gases.

Gagetron

14 An atomic energy-operated device which measures catalyst level in a Houdriflow catalytic cracking unit is being manufactured by the Brown Instruments Division, Station 40, Minneapolis-Honeywell Regulator Company, Wayne and Windrim Avenues, Philadelphia 44, and is known as a "Gagetron." Developed by Instruments Incorporated of Tulsa, for catalyst level control, the device is applicable for the measurement of all liquid levels and fluid densities through container walls, thus eliminating seals, stuffing boxes, etc. Instrumentation Data Sheet 10.4-1a.

Automatic Distillation

15 An automatic apparatus which performs various ASTM tests and charts temperature, records time, controls heat, and varies distillation rate is manufactured by Precision Scientific Company, 3737 West Cortland Street, Chicago 47, under the name, Precision-Shell automatic distillation apparatus. Developed jointly by Precision and by Shell Development Company, the apparatus is said to perform ASTM test D 86, distillation of gasoline, naphtha, kerosine and similar petroleum products; D 268, sampling and testing of lacquer solvents and diluents; D 1078, distillation range of lacquer solvents and diluents; D 447, distillation of plant spray oils. With slight modification, the instrument can be used for D 216, distillation

of natural gasolines. It is also applicable for organic chemistry industries and for testing or industrial control laboratories, says the manufacturer.

Block Insulation

16 A folder on Superex block insulation offered by Johns-Manville, 22 East 40th Street, New York 16, lists information on advantages and properties of this insulation as well as giving conductivity, heat loss graphs, and recommended thickness. Illustrated are a few of the many special shapes in which Superex can be furnished. Some applications for Superex are boiler furnaces, hot blast stoves, mains and bustle pipes, petroleum cracking furnaces, etc.

Gate Valves

17 R-P&C Forged Steel Gate valve, designed for the high pressure field, is manufactured by the R-P&C Valve Division, American Chain & Cable Company, Inc., Reading, Pa. It features a bolted bonnet which is said to insure maximum service life and low cost maintenance, tongue and groove joint with soft iron gasket to provide tightness under varying service conditions and extremely hard wedge facing that minimizes seizing, galling and abrasive wear. Stainless steel gland bolts and nuts prevent freezing or corrosion while the two piece gland and follower applies pressure on the packing. Available ¼ to 2 inches.

Pre-Fabricated Piping

18 Western Piping Supply Division of the Lummus Company, 504 West 145th Street, East Chicago, Ind., has prepared a new bulletin "Pre-Fabricated Piping." The illustrated booklet discusses advances made in the field of high and low pressure piping subassemblies, and describes and pictures pipe bends, coils, headers, manifolds, Vanstone work, process piping, and welded assemblies produced in the Division's shops for the petroleum refining, pipe line transmission, chemical and heavy industries.

Welding Fittings and Joint

19 Welding fittings and joint for corrosion resistant coated piping, manufactured by Welstrom, Hamilton, Ohio, are available in all standard sizes and types of welding fittings and joints from one-half inch up to 30 inches in diameter. Coated or lined with corrosion-resistant coating in the plant, the small area affected can be re-treated with cold setting coating after being impaired by the welding procedure. The inside surface affected by the welding is treated through a threaded opening. The opening is then sealed with a pipe plug.

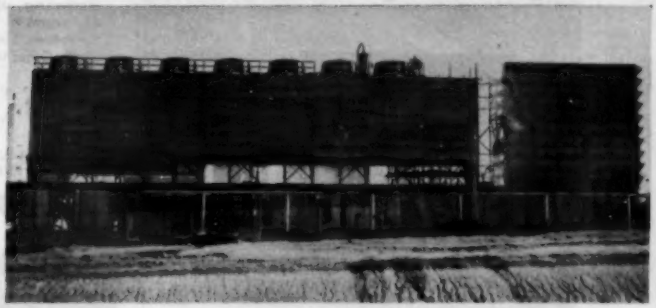
New Equipment

(For additional information or literature check item numbers on mailing coupon, page 211, or write manufacturer direct.)

Any alterations which are necessary for field assembly, resulting from slight changes in design layouts, can be made in the field.

Hydraulic Control

20 A new hydraulic remote control system is offered by Superdraulic Corporation, 14256 Wyoming Avenue, Detroit 4. The system consists of a master unit and a slave unit interconnected by two small tubes. Motion applied to the actuating lever of the master unit is accurately duplicated by the



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COOLING TOWERS

from atmospheric type to INDUCED DRAFT

- IMPROVES PERFORMANCE
- CONSERVES GROUND SPACE
- RESTORES CONDITION
- ENHANCES APPEARANCE
- REDUCES WATER SPRAY LOSS

These and other profitable advantages are available through HUDSON inspection and repair services.

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FAIRVIEW STATION • HOUSTON, TEXAS

IS VACUUM THAT'S 99.99% PERFECT

good enough for your process?

THIS degree of vacuum is easily obtained with the Croll-Reynolds four or five-stage steam jet EVACTOR, with no moving parts. Each stage from a technical standpoint is as simple as the valve that turns it on. Numerous four-stage units are maintaining industrial vacuum down to 0.2 mm. and less, and many thousands of one, two and three-stage units are maintaining vacuum for intermediate industrial requirements on practically all types of processing equipment.

By permitting water, aqueous solutions or any volatile liquid to evaporate under high vacuum and without heat from an outside source, enough BTU's can be removed to chill the liquid down to 32° F., or even lower in the case of solutions. This is the principle of the Croll-Reynolds "Chill-Vactor." Hundreds of these have been installed throughout the United States and in several foreign countries.

An engineering staff of many years experience has specialized on this type of equipment and is at your service. Why not write today, outlining *your* vacuum problem?

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CROLL-REYNOLDS CO., INC.

17 JOHN STREET, NEW YORK 38, N. Y.

Chill-Vactors Steam Jet Evactors Condensing Equipment

Tempilstiks°

The amazing CRAYONS that tell temperatures

For heat-dependent operations, control temperatures with TEMPILSTIKS°. Simplicity, accuracy, and economy have made them standard equipment in thousands of industrial plants. Available for 56 different temperatures from 113° to 2000°F—one for every temperature commonly specified for ***welding, flame cutting, tempering, forging, casting, molding, drawing, straightening,*** and scores of other heating operations. Eliminate guesswork. Order today.

$2 each gives up to 2000 readings

ALSO AVAILABLE IN LIQUID OR PELLETS

it's this ***SIMPLE***

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2. Mark your workpiece with it.
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BIG THREE WELDING EQUIPMENT CO.

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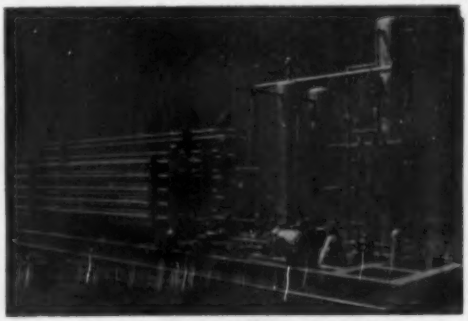

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This Package Unit, less the Absorber and Still, installed in an Oklahoma field, is but one example of our skill in engineering and rigid adherence to specifications.

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SUPERIOR MANUFACTURING COMPANY

AMARILLO, TEXAS

New Equipment

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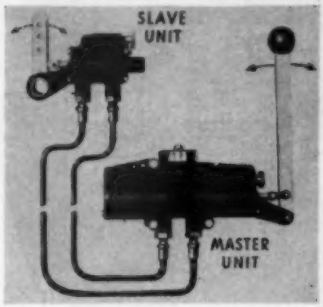
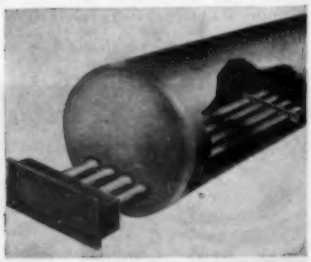


slave unit lever. It is said to have load carrying ability in both directions because its operation is not dependent upon springs, compressed air or valves. The system provides for expansion and contraction of both fluid and metal due to temperature changes in a manner that guarantees synchronization between master and slave units, it is claimed. An automatic lock in the slave lever provides for irreversibility. Eliminates bell cranks, rods, linkage, etc. Capable of handling 500 inch-pounds of torque.

Tubular Heaters



21 A line of tubular heaters that provides low density electric heat for oils, tars, resins and other viscous fluids has been marketed by the Hynes Division of the Martin-Quaid Company, 1876 Sedgley Avenue, Philadelphia 32. It is said to differ from the "immersion heaters" in that the design permits large input capacity without exceeding critical heat density limitations of the fluid being heated. Problems of carbonization and "other forms of fluid breakdown resulting from local overheating are eliminated." The heaters are installed without liquid joints and the internal heating elements can be removed from the tube enclosures at any time without draining fluids from the vessel. The heaters are "not liable to mechanical damage and are available in moisture or explosion-proof models." Bulletin 201.

Tile Conduit

22 "Therm-o-Tile Underground Pipe Conduit," a booklet, has been published by H. W. Porter & Company, Inc., of Reid Hayden, Inc., Insulation Engineers and Contractors, 825

SPECIAL FIRE HAZARDS
CALL FOR SPECIAL PLANNING
Hidden in the maze of piping required for this Butadiene storage area are the water lines supplying a Blaw-Knox Fog Nozzle System which is operated by rate-of-rise thermostats. Careful planning by specialists in industrial fire protection assures the most effective means for instantly quenching any "hot spot" in such hazardous locations. Without obligation we will be pleased to submit a preliminary layout together with an estimate of costs for the type of system best suited to your needs.
BLAW-KNOX SPRINKLER DIVISION
OF BLAW-KNOX CONSTRUCTION COMPANY
829 Beaver Ave., N.S., Pittsburgh 12, Pa.
Offices in Principal Cities
"LITTLE JOEY SPRINKLER"
BLAW-KNOX PROTECTIO SYSTEMS

New Equipment

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Frelinghuysen Avenue, Newark 5, N. J. Therm-o-Tile "is a complete conduit system for the permanent protection, support, and insulation of underground pipe lines." Bulletin 511 describes a monolithic "sidewalk" base; an emergency internal drain; strong arch and tile construction; pipe supports carried by the concrete base which do not stress the conduit; tight and waterproof construction; provision for the two principal types of insulation; easy accessibility; adaptability to take care of all pipe sizes and number of pipes. Size 8½ by 11 inches.

Electrical Chart

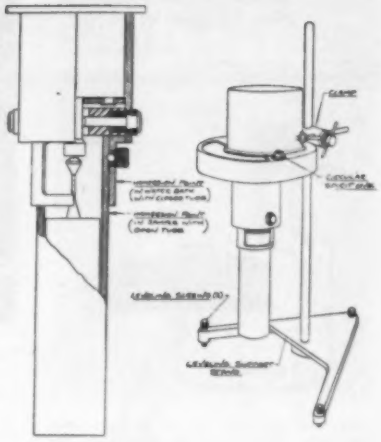
23 Thermo Electric Company, Inc., Fair Lawn, N. J., has printed an 8½ by 5½-inch chart showing the applications, calibration symbols, conductors, polarity and Thermo electric, ISA, and military color codes of thermocouple and extension wires. Resistance tables for these wires are shown on the reverse side of the card.

Turbines

24 The Terry Steam Turbine Company, Hartford 1, Conn., has published a bulletin featuring Terry GAF and ZAF multi-stage turbines. It discusses the overspeed governor, governor valves, blades, diaphragms and many other items, and also gives dimensional drawings of the two turbine types.

Viscosity Measurements

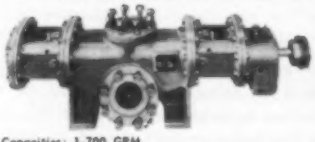
25 Brookfield Engineering Laboratories, Stoughton, Mass., offer a UL Adapter for their LV model of the Brookfield Viscometer. This special attachment is said to make possible extremely precise measurements in ultra-low viscosity ranges. The adapter consists essentially of a cylindrical spindle mounted symmetrically within a concentric tube. When attached to the LV model of the Brookfield Viscometer, it gives full scale (13 ½ inches) deflections representing ten centipoises at 60 RPM, and 100 centipoises at six RPM. Because of amplifying effects provided, says Brookfield, when measuring viscosities within the range of zero to ten centipoises, reproducibility within .02 centipoises is obtainable. Immersible parts of the Adapter are made of 18/8 stainless steel.



Thermal Conductivity

26 Gow-Mac Instrument Company, 22 Lawrence Street, Newark 4, N. J., has a P-Kem special assortment of thermal conductivity cells which consists of a sensitive unit with a signal strength of 60 mv. for one percent H_2 in air, equivalent to better than ten parts per million in useful recorder deflection, through a three-part range to a fast acting sensing element which can give up to five determinations per minute in enriched oxygen atmospheres. The unit consists of three sensing elements and a current control net-work for the 15 minute set-up of the working circuits required for their use. The Gow-Mac M/T-T-8 is a research unit of high output, with negligible current zero shift over a 40 milliampere range; the Gow-Mac Standard, an all purpose unit, is good for student use, being indifferent to wide changes in rate of sample flow; and the Gow-Mac Model 60-S, which completes its response even for many heavier gas mixtures in less than 60 seconds. Bulletins.

PUMP CRUDES, ASPHALT, DISTILLATES, WAXES?



The NEW Sier-Bath
External Gear & Bearing Bracket Type
SCREW PUMP

Capacities: 1-700 GPM
Discharge: 1000 PSI for viscous liquids
300 PSI for water

provides greater dependability, longer life . . . costs less to service and maintain

NEW FEATURES:

Single-point Alignment. Just one support point—base of pump body. External housings bolted directly to pump body, thus eliminating bearing strain and rotor misalignment due to change of position of pump elements.

"Dual-controlled" Rotors for less wear on bearings and timing gears. *Axial* control by heavy-duty thrust bearings—*radial* control by precision cut timing gears and heavy-duty roller bearings.

Faster Servicing—gear housings center line supported, doweled for accurate alignment. All parts automatically positioned by shoulders and locknuts.

ADDITIONAL ADVANTAGES:

Less Strain on Valves and Piping—pulseless discharge, no hammer or vibration.

No Metallic Contact Between Rotors sustains high volumetric efficiency.

High Volumetric Efficiency reduces wear caused by erosion.

Only Suction Pressure on Stuffing Boxes reduces packing maintenance.

Direct-connected up to 1800 RPM.

Available in corrosion resistant alloys. Special bodies, stuffing boxes and bearings for high temperature applications. Hopper type bodies for extremely high viscosities. Sier-Bath "Gearex" Pumps for lower pressures and capacities.

Sier-Bath
GEAR and PUMP CO., Inc.

WRITE FOR FURTHER INFORMATION
9249 HUDSON BLVD.
NORTH BERGEN, N. J.

Also Manufacturers of Precision Gears and Flexible Gear Couplings

Asbestos Gaskets

27 Pars Asbestos Gaskets, constructed for service where surfaces are rough or uneven and subject to considerable expansion and contraction, are manufactured by Lawton H. Parsons, 6 South Main Street, Ambler, Pa. The gaskets are used to hold steam, air, water, ammonia, and other acid and alkali chemicals in storage tanks, cookers, dryers, laundry machinery, locomotives, tank cars, boilers and locomotive service. Standard sizes flanges are 3/16 inch thick and 7/16 inch wide, and i.d. from 2½ to 18 inches. Special gaskets can be ordered for irregular shapes and sizes.

Binding Steel Strapping

28 For pulling steel strapping of ⅜, ½, ⅝ or ¾ inches tight around any size or shape object, A. J. Gerrard & Company, 1950 Hawthorne Avenue, Melrose Park, Ill., have developed a handy addition to the line of

a new guide to better operation

through effective resistance to corrosion, heat and abrasion

Here's a brand new catalog containing detailed information on stainless and high alloy equipment that will help you overcome the problems of corrosion, heat and abrasion in your refinery.

In addition to an explanation of the different types of corrosion and recommended analyses for meeting the various corrosion problems, the catalog includes data on the following:

- **Heat resistant castings**
- **Abrasion resistant castings**
- **Centrifugally cast pipe and bushing stock**
- **Dimensions on screwed, flanged and welding fittings**
- **Corrosion resistant valves**
- **Corrosion and heat resistant conveyor chains**
- **Wrought stainless pipe, tubing, light wall fittings**
- **Useful tabular data on bars, tubing, fittings, etc.**
- **Corrosion resistance of principal alloys to most common corrosive agents**

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Please send me your new catalog, "ESCO Stainless and High Alloy Products".

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New Equipment

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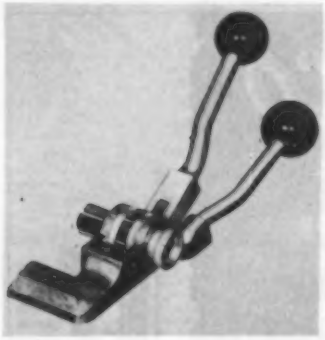


Steelbinder strapping tools, known as the No. 120 Steelbinder. It operates like the larger tools but does not cut off surplus strap as an integral part of the binding action. The strap is cut with a hammer cutter. Shortened handles adapt the No. 120 to close-quarter work, as on ladders, scaffolding, etc. Tool can be carried in an overalls pocket when not in use. It provides same "tighter tie" as other tools of its line because it places no wedge between the strap and the object tied.

Welding Equipment

29 A circular on protective equipment for welders, published by Willson Products, Inc., Reading, Pa., describes a wide range of eye protective devices for both gas and arc welding, and includes product information on respiratory protection for welders. Accessories such as rubber mask padding for goggles, and the Weld-Aid lens for welders who wear bifocal glasses are described; also various type of filter glass and a selector chart of types and shades for different welding operations.

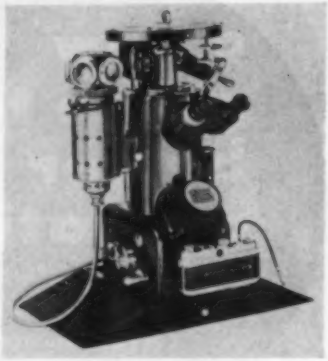
Liquefied Gas

30 A booklet summarizing the production, handling and storage of liquefied gases has been published by Arthur D. Little, Inc., Memorial Drive at Kendall Square, Cambridge 42, Mass. Brief descriptions of the ADL Collins helium cryostat, hydrogen liquefier, liquid oxygen generator, helium refrigerator and liquid-oxygen pump, all applicable to work with liquefied gases or to low temperature investigations, are given, as well as engineering services available and various other equipment. "New Products and Services, 1951."

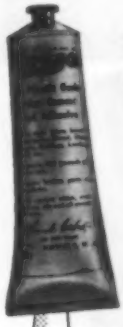
Safety Head

31 "Safety Head" Catalog by Black, Sivalls & Bryson, Inc., Advertising and Sales Promotion Dept., 7500 East 12 Street, Kansas City 3, Mo., is arranged for easy reading, and written in non-technical language. The catalog is illustrated with cutaway drawings and installation photos. Numerous tables and charts cover desirable information.

Metallograph



32 Rapid, low cost structural analysis of metal samples and other substances with speed, accuracy and thoroughness is claimed of the Griswold OPL Metallograph by F. T. Griswold Manufacturing Company, Wayne, Pa. Facilities for examination, study and photographic reproduction necessary from research to routine testing, is said to be possible in the one unit. A large assortment of objectives, ocular and projective lenses, parfocal and parcentered, coated on all air-glass surfaces and corrected for infinitity, are included. The OPL Metallograph occupies table space twelve by twelve inches, and overall height is 18 inches. Controls provide



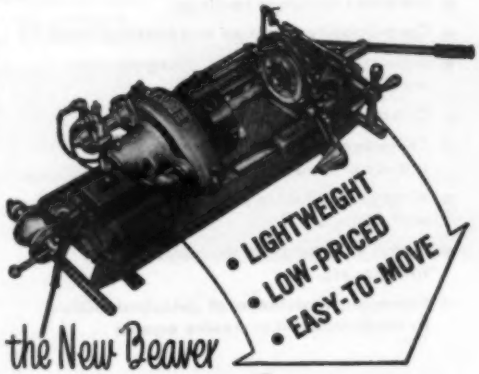
MAKE IT LEAK-PROOF WITH *Plasgon*

Cabot's PLASGON is the best sealer for pipe joints on the market — because it's a flexible plastic sealer, unaffected by oil, gasoline, glycol, water, steam or other common solvents. Stands heat up to 350° F.

Excellent for making leak-proof gaskets — quickly. Makes a permanently tight seal that withstands shock and jarring.

Write Today for free sample of Plasgon and complete information. Samuel Cabot, Inc., 624 Oliver Bldg., Boston 9, Mass.

CABOT'S *Plasgon*



the New Beaver Model-E Pipe and Bolt Machine

The new low-priced, lightweight Beaver Model "E" is a "junior edition" of the heavy-duty Beaver Model A—which has, for the past 20 years, been the recognized leader in the field of portable pipe and bolt machines.

Although designed primarily for hardware stores and small piping contractors and industrialists, BIG contractors will find the new Model "E" useful on jobs requiring extreme portability.

A pipe machine is no better than the service back of it and our 50 years of experience in this field, and our reputation for high quality and friendly service, is your best guarantee of complete satisfaction.

WRITE FOR NEW "OPERATING 'HINTS' GUIDE"

BEAVER PIPE TOOLS

252-300 DANA AVE. WARREN, OHIO, U.S.A.

Interior of this soaker is lined with welded 4" x 24" stainless steel strips. Down to the last weld of the last seam, stainless steel offers positive resistance to rust and corrosion.
LONG LIFE...
LITTLE MAINTENANCE

THIS STAINLESS STEEL soaker lining has been in operation for several years. It is typical of the many refinery applications in which stainless steel has *proved* its long-life qualities. In fact, superior service prompted the operators of this refinery to state that "stainless steel has lasted longer and required less maintenance than any other commercial material previously used."

All along the refinery line, Republic ENDURO Stainless Steel is busy stretching equipment life, cutting downtime for repair and replacement, keeping equipment on-stream, conserving other critical materials.

ENDURO resists rust and corrosion. It fights off the attacks of destructive gases and fumes. It maintains its great strength at wide temperature extremes. Its smooth, pore-free surface discourages coking and fouling, is easy to wash down when needed. ENDURO lasts.

Competent Republic metallurgists can help you use the available analyses of Republic ENDURO Stainless and Heat-Resisting Steels to best advantage. Just write:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

Republic
REPUBLIC STEEL
ENDURO STAINLESS STEEL

Other Republic Products include Upset Bolts, Studs, Nuts and Rivets—Pipe—Sheets—Plates—Electrunite Heat Exchanger Tubes

NOW EFFICIENT DESALTING IS MORE IMPORTANT THAN EVER

TD 81-2 *Photo courtesy Standard Oil Company of Ohio.*

. . . because efficient salt removal can be an important factor in a refinery steel conservation program.

HERE'S HOW

1 Salt carried over promotes the evolution of hydrochloric acid, a severe source of corrosion, especially in the overhead sections. Efficient desalting helps to prevent metal losses due to this kind of corrosion.

2 Salt in the crude charge causes the deposition of hard, flinty coke in furnace tubes, frequently resulting in hot spots and tube failures. Also the rigorous cleaning measures required to remove hard coke are a source of tube wear and metal losses. Efficient salt removal prevents the formation of hard coke.

TRETOLITE DESALTING *has a definite place in your steel conservation program*

Tretolite chemical desalting has proved its high efficiency in refineries everywhere. In plants with throughputs varying from 2000 b.p.d. to 50,000 b.p.d., the Tretolite process is desalting well over a million barrels daily. Salt removal percentages are in the 90 to 95% range with extremely low water, heat and chemical requirements. The flexibility of the Tretolite desalting process often permits the incorporation of existing refinery equipment in the flow scheme, holding the need for scarce new material and equipment at a minimum. Why not discuss desalting with a Tretolite engineer soon?

TRETOLITE COMPANY

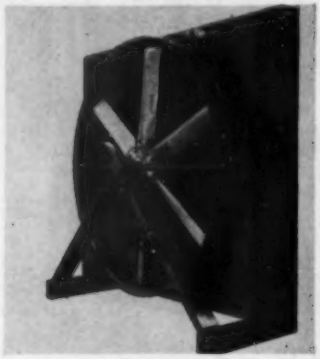
Chemicals for the Petroleum Industry

ST. LOUIS 19, MISSOURI LOS ANGELES 22, CALIF.

DESALTING • DEHYDRATING • WATER DE-OILING • CORROSION INHIBITION • SCALE PREVENTION • PARAFFIN REMOVAL

for manipulation of variables. Photographs on 35 mm roll film can be made by swinging the image from the ground glass to the camera.

Jacket Water Cooler



33 Young Radiator Company, Racine, Wis., is marketing an "improved" engine jacket water cooler, all "Mono-Weld" steel units. Base extensions, which are optional, permit mounting the motor and/or pump to the framework. A cross channel is welded to the base extensions for strong, rigid, integral framework. The "A" frame fan-support is of rugged welded heavy steel channel which provides greater strength, and minimum resistance to air flow, according to the company. A fan guard protects operators and the core while two-piece construction, bolted to the fan ring, insures ease of access for cleaning and fan service. Sheaves and V-belts are of standard size and four or five V-groove sheaves use two and three grooves for the power drive; one or two for pump as required. Vertical water flow, heavy formed steel channel side members, steel side supports for cores, press-formed heavy weight non-ferrous headers are among other new features. Catalog No. 1351.

Pumps, Heat Exchangers

34 A bulletin on Nu-Kast pumps and heat exchangers designed for transfer of corrosive liquids, hot or cold, is published by Nukem Products Corporation, 111-119 Colgate Avenue, Buffalo 20. Nu-Kast pumps are made of cast resins, consequently no metal is in contact with the solutions. The transfer range is up to 100 gpm. at varying heads. The Nukem-Karbate heat exchangers are light, compact units with short, straight runs, utilizing the acid resistance of non-metallic materials. They are said to be flexible and versatile, circulating the solutions at high velocity. Will raise solution temperatures 110° F. in two and one-half hours and may also be used for cooling purposes.

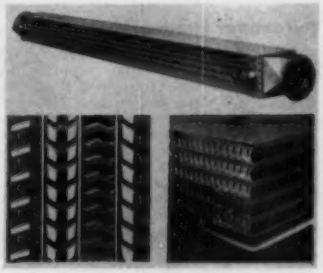
Metallic Piston Rings

35 Thirteen different types of metallic piston rings are described in a new catalog edition distributed by the Double Seal Ring Company, P. O. Box 550, Fort Worth, Texas. It contains explanations of the uses of the rings listed, large illustrations, and instructions for ordering. Drawings of typical ring installations in two and four-cycle diesel or gas engines, ammonia compressors, pneumatic compressors, steam engines and pumps, plus general information and recommendations on piston ring matters are special features of the improved catalog.

New Equipment

(For additional information or literature check item numbers on mailing coupon, page 211, or write manufacturer direct.)

Solvent Recovery



36 Modine Manufacturing Company, Industrial Division, Racine, Wis., has developed and marketed a new plate type heat exchanger especially designed for solvent recovery. Incorporating interlocked channel type fins with special embossings or interrupted

RECALIBRATE *on the job—* *Rochester* DIAL THERMOMETERS

Accidents are bound to happen . . . like dropping or banging a thermometer sufficiently hard to make readings inaccurate. This could result in costly production errors. To eliminate this possibility, Rochester now offers a new bi-metallic Dial Thermometer with screw adjustment permitting recalibration on the job! Simply put the instrument in boiling water or other known temperature and reset indicator. Better order today. Send for Catalog No. IT-650, Rochester Manufacturing Co., Inc., 38 Rockwood St., Rochester 10, N. Y.

ROCHESTER MANUFACTURING COMPANY, INC.
DIAL THERMOMETERS . GAUGES . AMMETERS
ROCHESTER GAUGES

Facts on Faster Cleaning—FREE!

PACKED with helpful cleaning information, this 32-page booklet helps cut maintenance cleaning costs to the very bone. Here, for example, you'll find how to save money cleaning towers; descaling heat exchangers; conditioning barrels and drums; cleaning tank car interiors, many other maintenance cleaning operations.

These Oakite cleaning methods are proving most successful time- and money-savers for many of the nation's leading petroleum producers, refiners, marketers. Get your FREE copy today! No obligation, of course. Write Oakite Products, Inc., 50B Thames Street, New York 6, New York.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS • METHODS • SERVICE
Technical Service Representatives Located in Principal Cities of United States and Canada

New Equipment

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surfaces, Modine claims the design provides unusually high concentration of surface for low weight and volume. Surface area ranges from 250 to 300 square feet per cubic foot, permitting substantial cost savings over conventional heat exchangers used for solvent recovery. Shown at top is new plate-type heat exchanger designed for solvent recovery; left, interlocked channel-type fins; and right, typical internal arrangement of passages and channel-type fin surfaces.

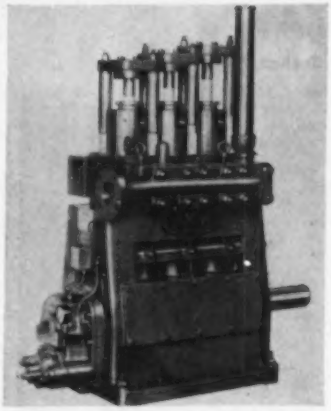
Pyrometer Supplies

37 Five new items have been added to its pyrometer supplies by Minneapolis-Honeywell Regulator Company, Brown Instruments Division, Wayne and Windrim Avenues, Philadelphia 44. 1) Cast iron, closed-end **protecting tube** for molten aluminum application features a service life several times that of former models according to M-H. The tube is described as being of dense cast iron having a smooth outer skin, with 1-15/16 inch o.d. by 13/16 inch i.d. It comes in 12, 18, 24, 30 aid 36 inch lengths. 2) A two-conductor, 24-gauge copper constantan **thermocouple wire** developed specifically for refrigeration application. The model has a moisture-proof polyvinyl-chloride insulation. Over-all dimensions are approximately 3/64 by 3/32 inches. Field tests have determined a temperature range of minus 20° to plus 225° F. It is said to contain a high moisture and abrasive resistance and has "safe" flexing within temperature limits. 3) A portable **immersion, removable-tip thermocouple** developed for measuring temperatures of molten steel in foundry holding and transfer ladles. It is credited with accurate readings in 15 to 25 seconds of immersion time in molten steel having a carbon content of 2.5 percent or more, through a range from 2400° to 2900° F. 4) A 20-gauge JX and KX **two-conductor insulated extension wire,** with standard ISA wire color coding in both iron - constantan and Chromel - Alumel components. Each wire is insulated with enamel, covered by moisture and flame resistant, wax-impregnated asbestos. Conductors are covered over with a heavy Fiberglas braid. 5) A one-inch IPS **resistant protecting tube** has been standardized and tested for thermocouple protection in heat treating furnaces, etc. Recommended high measuring temperature is 1800° F.

Heat Transfer Surfaces

38 Heat Transfer Surfaces, a bulletin issued by Modine Manufacturing Company, Industrial Division, Racine, Wis., describes a wide variety of specialized heat transfer surfaces which Modine has developed for industrial products and processes. Surfaces illustrated are applicable to such equipment as solvent recovery, intercooling, regeneration, gas separation and liquefaction, heat economizing and drying. Included are types providing as much as 300 to 350 square feet of surface per cubic foot of volume. Bulletin ID-151.

Direct Flow Pump



39 A three-inch Stroke Triplex, direct-flow pump which can operate at speeds up to 500 rpm. is manufactured by the Aldrich Pump Company, Allentown, Pa. Power ranges up to 50 hp., pressures up to 3800 psi., and displacement up to 96 gallons per minute at 790 psi., 500 rpm. The direct flow pump passes liquid in a straight line, directly through the working barrel. The fluid end is sectionalized in construction for simple and inexpensive maintenance. Plunger size is said to be readily changed to meet altered pressure and capacity demands. Data Sheet 64 A.

Pipe Corrosion

40 A brochure explaining how to stop service pipe corrosion with tape is published by the Minnesota Mining and Manufacturing Company, 900 Fauquier Street, St. Paul 6. "Scotch" brand electrical tape Number 22 is said to be effective in combating corrosive action of moisture, alkalies, oils, fats, and fungi on underground gas service pipes. The publication lists six specific advantages of taped pipe. Application techniques are illustrated and the chemical, physical and electrical properties of the tape are given.

Furnace Walls and Arches

41 "Furnace Wall and Arch Construction," latest catalog published by Laclede-Christy Company, 3600 Forbes Street, Pittsburgh 13, describes many aspects related to refining including a metals section discussing Laclede arches as applied to aluminum, copper and lead furnaces. Other aspects of interest to the refining industry are the sections dealing with Laclede construction applied to down-draft heaters; to box-type and up-shot heaters; and to box type heaters.

Expansion-type Bellows

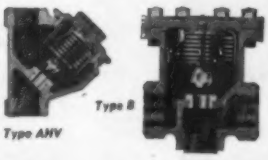
42 An expansion-type bellows for the absorption of high frequency vibration and lineal expansion is manufactured by Titeflex, Inc., 500 Frelinghuysen Avenue, Newark, N. J. Constructed of convoluted metal diaphragms welded into complete units, the bellows have been tested for application involving constant high pressures, corrosive

Large Processor Achieves

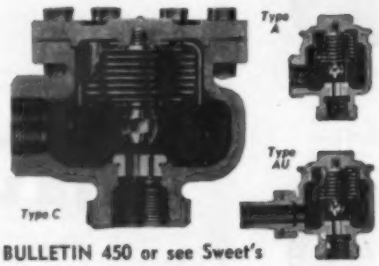
MORE UNIFORM HEATING CYCLES

With Nicholson Steam Traps

The positive action of Nicholson traps was recently used successfully by a chemical maker to smooth out the heating cycles of cookers at 50 to 60 minutes, against previous periods up to 105 minutes. Steam flow was upped to 3000 lbs. an hour against 2000 for the previous mechanical type.

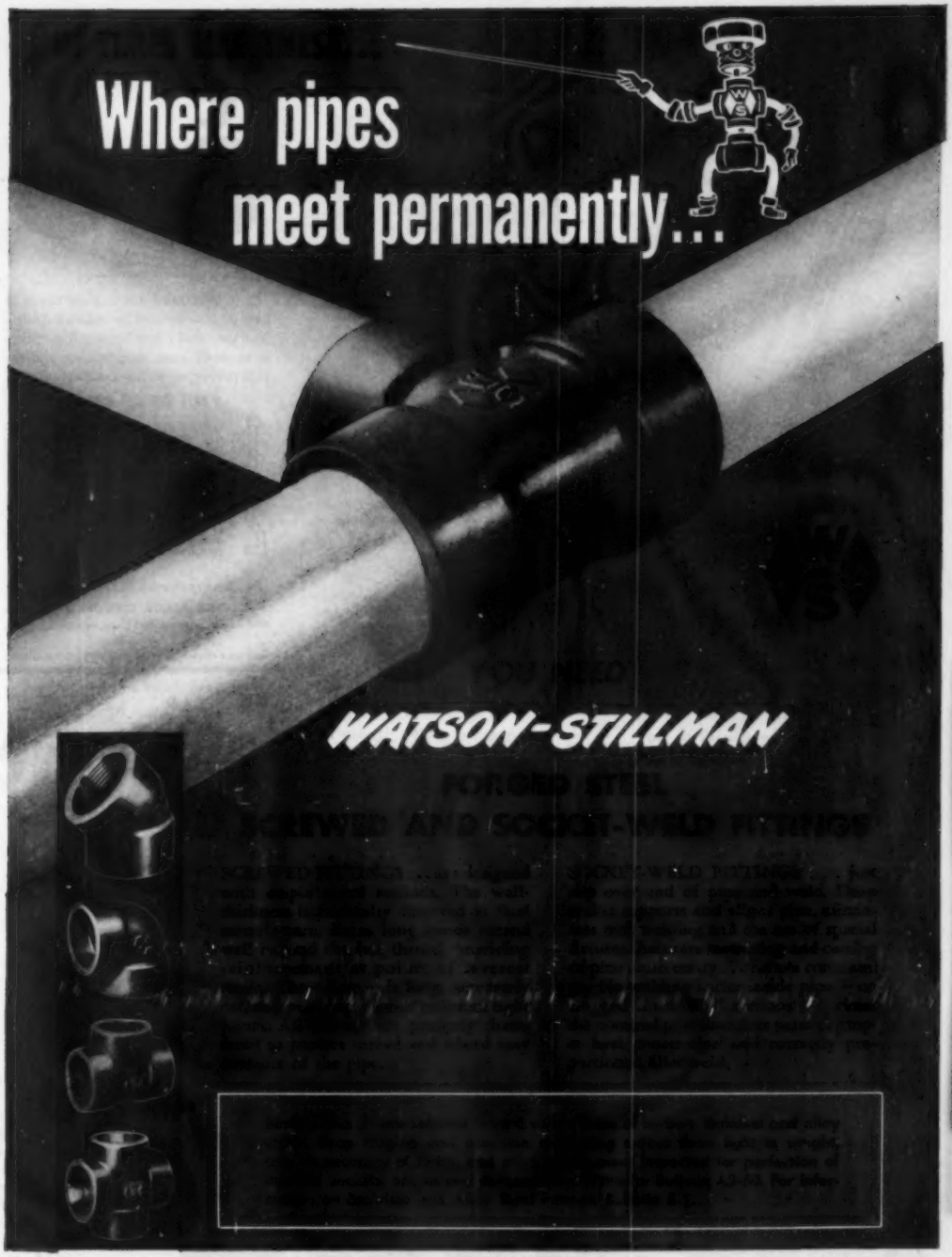


5 TYPES FOR EVERY APPLICATION, process, heat, power. Sizes ¼" to 2"; pressures to 225 lbs. To learn why an increasing number of leading plants are standardizing on Nicholson thermostatic traps . . .



Send for BULLETIN 450 or see Sweet's

W. H. NICHOLSON & CO., 207 Oregon St., Wilkes-Barre, Pa.



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Designers and Manufacturers of Forged Steel Fittings, Valves, Wire Rope Shears, Hand Pumps, Jacks, Pipe Benders and Hydraulic Equipment

Water levels are crystal clear with MACBETH GAUGE GLASSES
BRAND

In steam service, you can depend on Macbeth brand gauge glasses to stay crystal-clear permanently. They resist fogging, pitting, etching and staining . . . provide maximum visibility at all times, even at a distance.

OUTLAST ALL OTHER TYPES—Shock tests show that Macbeth gauge glasses can be heated to 425°F. and then plunged into ice water . . . *without breaking!* And the extremely low coefficient of expansion of Macbeth brand glasses permits heavier construction for additional mechanical strength . . . assures longer life than any other type of gauge glass. Precision made for accurate fit and easy installation, Macbeth Gauge Glasses provide inexpensive protection for your boiler investment. Available in plain, reflex, and high pressure types through your Mill Supply Distributor.

CORNING GLASS WORKS
CORNING, N.Y.

T.M. REG. PYREX U.S. PAT. OFF.

Gauge Glasses, Sight Glasses, Oil Cup and Lubricator Cup Glassware.

• 100 Years of Making Glass Better and More Useful •

New Equipment

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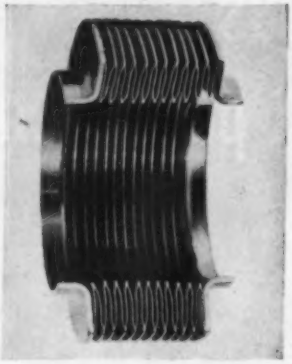

liquids, gases, and extreme temperatures in sealed piping systems. Available in sizes from 1 to 5 inches i.d. in various lengths, and in plain or stainless steels, brass, bronze, etc.

Piping

43 To demonstrate its experience and facilities for fabrication and erection of industrial piping, Dravo Corporation, Pittsburgh 22, has issued Bulletin 1700 picturing piping installations in steel mills, for gas transmission system, central power stations, water pumping stations, heating plants, oil refineries, and chemical process plants. Dravo's engineering and fabrication facilities are also described.

Optical Parts

44 Bausch & Lomb Optical Company, Rochester 2, N. Y., has published a catalog especially edited for research and engineering needs. Titled "Optical Parts," the catalog gives optical supply specifications, explains terms not liable to be familiar to the layman. It is "published to eliminate a lot of needless correspondence and to cut down on costly 'tailor made' optics."

Heavy Lifting Equipment

45 American Hoist and Derrick Company, St. Paul 1, Minn., has issued "American Wire Rope Blocks and Sheaves," Catalog 300-24, which advises what factors to consider in ordering blocks and sheaves, gives specifications, charts to figure line parts, ratio tables and instructions for using them. Rope blocks, snatch blocks and crane blocks also are covered.

Couplings

46 Coupling Specification Sheet Number 451-C, listing dimensions of line, railroad, merchant, water well, and other pipe couplings, is offered by Capitol Manufacturing & Supply Company, 153 West Fulton Street, Columbus 16, Ohio. Compiled for easy reference, specifications follow the recommendations of the American Iron & Steel Institute, the API, etc.

Whether your cooling tower is new or old—natural or induced draft—let a qualified Fluor Service Representative study your maintenance and repair problems—at no cost to you!

2 FREE SERVICES AVAILABLE

1 PREVENTATIVE MAINTENANCE — Fluor will recommend a preventative maintenance program based on operating conditions and locale—and then arrange for periodic inspections!

2 ESTIMATES FOR REPAIR—Fluor will inspect to determine repairs necessary to bring your tower back to original design efficiency—then bid for the job competitively!

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anti-corrosive strapping and seals

A. J. Gerrard Metals and Finishes enable you to meet the corrosive conditions to which pipe lines and tanks are subjected.

MONEL
STAINLESS —TYPES 304, 316
GALVANIZED STEEL
COPPER
ALUMINUM
BRASS

Also Tools for Applying.

FREE

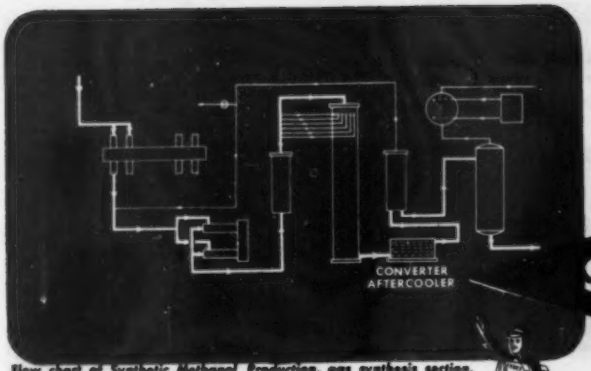
Handy calculator—one side tells you which strap to use for any given corrosive condition; the other side determines length and weight of strap required for any binding operation.

A. J. Gerrard & Co.
1956 Hawthorne Ct., Melrose Park, Ill.
(Chicago Suburb)

SM-4

let's take a closer look at

STRESS CORROSION



Flow chart of Synthetic Methanol Production, gas synthesis section.

Chloride solutions cause *pitting-corrosion* of stainless steel. Stresses on the material — whether those of construction or high-pressure operation — become localized at the root of the pits. Such stresses may reach sufficient local magnitude to cause stress-corrosion and, eventually, failure.

In this case Croloy 5 tubing was found to have superior resistance to initial pitting and consequently to the whole series of previous troubles.

Whatever the analysis needed, whether stainless grades, intermediate chrome alloys, or carbon steel, "Mr. Tubes" — your B&W Tube Co. representative — can help you solve your problems of tubing selection from B&W's complete range of types, sizes, grades, and finishes. Send for Technical Bulletin 6-E, Properties of Carbon and Alloy Seamless Steel Tubing for High-Temperature and High-Pressure Service.

Here's what happened to Stainless tubing (TYPE 347) when exposed to chloride-bearing bayou water while conveying methanol and unreacted synthesis gases at 300 F and 5000 psi. Note transgranular branching cracks typical of stress-corrosion in pitted stainless steel.

Here's Croloy 5 tubing, after twelve months in the same service. Note absence of pitting and stress-corrosion. Wall thickness was not appreciably reduced.

THE BABCOCK & WILCOX TUBE COMPANY

***Executive Offices:* Beaver Falls, Pa.**

General Offices and Plants

Beaver Falls, Pa.— Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio — Welded Carbon Steel Tubing

Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 3, Ill. • Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich. • Houston 2, Texas • Los Angeles 15, Calif. • New York 16, N. Y. • Philadelphia 2, Pa. • St. Louis 1, Mo. San Francisco 3, Calif. • Syracuse 2, N. Y. • Toronto, Ontario • Tulsa 3, Okla.

TA-1629 B

GERONIMO
FOR THE SAFETY OF YOUR MEN IN REFINERIES AND NATURAL GASOLINE PLANTS
ESCAPE DEVICE
NET WEIGHT 15 LBS.
GLIDE TO SAFETY ON GERONIMO
(Patent Applied For)

GERONIMO will stand hardest wear and give unfailing protection to refinery and derrick men whose lives are endangered by fire, escaping gases or other hazards.

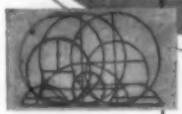
EASILY ATTACHED OR REMOVED
EXTRA STURDY CONSTRUCTION
QUICKLY STRADDLED

POSITIVE, INSTANT BRAKE
BRONZE "No-Spark" SURFACES
RECOMMENDED FOR ½" WIRE LINE

* Write for Illustrated Folder *

— MANUFACTURED BY —
CHARLIE'S MACHINE WORKS
PERRY, OKLAHOMA

CHICAGO-WILCOX GASKETS
Proved in Service in the Refinery Industry



GASKETS FOR HEAT EXCHANGERS, COOLERS AND CONDENSERS

Gaskets cut from solid metal, sheet-packing, or double jacket type as needed.

Corrugated metal gaskets for refinery use. Made of ingot iron, Terne-plate, aluminum, stainless steel and monel in sizes from 1 inch up.

A.P.I. ring gaskets for high pressure lines for use on ring-type flanged joints. Made of soft iron and all standard steel alloys in oval and octagonal shapes.

See page 252 in the Refinery Catalog.

CHICAGO-WILCOX Mfg. Co.
7703 Avalon Avenue
Chicago 19, Illinois

About EQUIPMENT and SERVICE Suppliers

Tipton Heads Hays Project Engineers; Heming Promoted

The Hays Corporation, Michigan City, Ind., has announced the appointments

Heming

Tipton

of Jack J. Tipton as chief project engineer, and of John R. Heming to the position of project engineer in charge of combustion control.

Tipton's new duties will be to oversee the acceptance and handling of orders for Hays products, including draft gauges, gas analysis instruments, electronic equipment and combustion control. He has been with Hays since 1945.

Heming succeeds Tipton as project engineer and will be in charge of all engineering data needed to complete control orders. He joined Hays in 1936 after graduation from Purdue University.

American Meter Company Elects Diehl, Hamilton Top Execs

John C. Diehl, president since 1950, was elected chairman of the board, and W. G. Hamilton, Jr., former vice president in charge of sales, was elected president of the American Meter Company, Inc., New York.

Other officers elected were: A. F. Benson, vice president engineering; C. B. Dushane, Jr., vice president sales; A. E. Weingard, vice president production; D. C. Wiley, vice president research; D. C. Struble, vice president purchasing; A. E. Norton and A. McW. Wolfe, vice presidents; T. A. Bracken, Jr., treasurer; W. B. Ashby, secretary; A. L. Smith, assistant secretary; A. McBeath, controller; E. J. Mowry, personnel director; L. F. McDonald, general traffic manager.

Boncher Named Vice President Dresser Industries at Dallas

Hector P. Boncher, general manager of Dresser Manufacturing Division, has been elected vice president of Dresser Industries, Inc., of Dallas. Boncher, Wisconsin born, holds a degree of commercial engineer from the University of Cincinnati. He was appointed assistant sales manager of Dresser Manufacturing in 1930.

Reelected officers were: H. N. Mallón, president; J. B. O'Connor, executive vice president; R. E. Reimer, vice president, secretary and treasurer; C. Paul Clark, vice president; Arthur R. Weis, vice president; M. H. Nelson, assistant secretary. This was the first board meeting held since the firm moved its headquarters from Cleveland to Dallas.

Pryor Joins W-K-M Company; Gallman Moved to Houston

W-K-M Company recently added two men to its Houston organization. C. C.

Gallman

Pryor

"Red" Pryor joined W-K-M in the capacity of process application engineer and will devote his efforts to business with the gas and gasoline plants, refineries, and petrochemical phase of the oil industry. Pryor formerly was associate editor of PETROLEUM REFINER. He holds a B.S. degree in natural gas engineering from A. & I. College at Kingsville, Texas. His headquarters are in Houston.

V. C. Gallman, former district representative in Tulsa, has been transferred to Houston as general sales representative and will supplement company representation in Houston as well as specialize in pipe line sales in the central United States.

Theo. Ferguson has been appointed West Texas district manager for W-K-M. He is a long-time employe and has under his supervision Clyde Cook who is moving his headquarters from Hobbs, N. Mex., to Odessa, Texas. Ferguson, well known throughout west and north Texas, has his residence in Midland.

Ferguson

J. E. St. Clair of Los Angeles has been appointed as agent for W-K-M Company in California, Washington, and Oregon. St. Clair long has been associated with a former agent of the

Tame those touchy hydrocarbons

with a BJ Stuffingboxless Pump

Engineered for safe, simple, economical handling of butane, propane, ethane and other volatile hydrocarbons . . .

CAN'T ESCAPE

Leakage of pumped fluid to atmosphere is impossible. The motor and close-coupled pump are totally enclosed in a sealed pressure vessel. There's no fire hazard or danger to property or personnel caused by leakage.

ABLE TO CONTAIN HIGH PRESSURES

BJ's pressuring system maintains a predetermined pressure across the mechanical seal that separates the motor from the pump within the chamber. This pressure is constant, regardless of suction and discharge pressures.

NO "KEEPER" NEEDED

No special attendant is needed to guard against leakage and consequently no costly maintenance time is spent in repacking and adjusting.

OPERATING SAVINGS

While the first cost of the BJ Stuffingboxless Pump is somewhat higher, big and continuing savings are offered in operation. There's no product loss through leakage, no downtime due to flood-out.

THE *RIGHT* PUMP FOR YOUR JOB

The BJ Stuffingboxless Pump is available in a wide range of models and pressuring system combinations to meet individual requirements. Byron Jackson Co. engineers are ready to help you secure the BJ Stuffingboxless Pump best suited to your job. Write, wire or phone today.

Byron Jackson Co.

Since 1872

Dept. 25, P.O. Box 2017 Terminal Annex, Los Angeles 54, Calif.

OFFICES IN PRINCIPAL CITIES

THESE BJ STUFFINGBOXLESS PUMPS handle ethane in a de-ethanizing operation. Pumping temperature is 80° F; suction pressure 490 psig; discharge pressure 520 psig; capacity 100 gpm; speed 3550 rpm; total head 165'; and specific gravity 0.42.

WHY BUY LESS

...the best costs so little

CM HOISTS AND PULLERS are ruggedly constructed to give you years of trouble-free service. Yet they are unusually light...easy to handle because they are constructed of the strongest alloys of steel and aluminum. Equipped with famous Herc-Alloy flexible, welded alloy steel chain.

- Capacities from ½ to 10 ton.
- 1-ton model weighs only 35 pounds.
- 96% efficient—easy to operate.
- Lifetime lubricated.

NEW CM CYCLONE

- Capacities ¾, 1½, 3 and 6 ton.
- ¾-ton model weighs only 13 lbs.
- Lifts or pulls at any angle.
- Lifetime lubricated.

NEW CM PULLER

Write for catalog and name of your nearest CM dealer.

CHISHOLM-MOORE HOIST CORPORATION

Affiliated with Columbus McKinnon Chain Corp.

GENERAL OFFICES AND FACTORIES: TONAWANDA, N. Y.

SALES OFFICES: New York • Chicago • Cleveland
San Francisco • Los Angeles

NEW HEADQUARTERS OPENED—Newly opened Houston headquarters of the Big Three Equipment Company features all-welded buildings. Big Three, manufacturers of oxygen and dealers for The Lincoln Electric Company of Cleveland, pioneered welding in the oil and gas fields in the 1920's, and even erected their first 20-by-40-foot building by welding pipe and sheet metal. The largest building on the old Eureka field site houses the latest type of equipment for manufacture of both liquid and gaseous oxygen. It also provides warehouse space for storing several hundred welders and 4 million pounds of electrode. Trucks can drive into the warehouse and be unloaded by fork-lift. A second building houses a self-contained repair operation for a new, unique method of production line overhauling of Lincoln welders.

W-K-M Company, Gene McIntyre, who died on April 5.

Day Appointed to Glendale As Factory Sales Engineer

Robert L. Day was appointed factory sales engineer of General Controls and will be headquartered at the Glendale, Calif., plant. Day was formerly senior sales engineer in the San Francisco factory branch office. His new job is to assist branch office personnel by handling technical inquiries from customers concerning heating, industrial and refrigeration controls made by the company. He has been associated with Aircraft Accessories Corporation as a liaison engineer, and with the Aerojet Engineering Corporation as a production engineer on jets and missiles.

Day

Hammond Licenses Two Firms To Fabricate Storage Tanks

Hammond Iron Works, Warren and Bristol, Pa., has licensed the Lacy Manufacturing Company of Los Angeles, and the Keyes Tank & Supply Company of Casper, Wyo., and Provo, Utah, to fabricate and erect all designs of Hammond Conservation Storage Tanks. These designs include the exclusive Hammond Dialift, Diaflote and Vaporlift tanks, as well as floating roof and pressure tanks. All are designed for product conservation and corrosion resistance. Lacy Manufacturing operates throughout the Pacific Coast and Hawaii; Keyes Tank & Supply Company throughout the Rocky Mountain area.

Cooper Distributor Named

Allied Metals, Inc., has been named Texas distributor of the Cooper Alloy Foundry Company of Hillside, N. J. Allied Metals already are associated with United States Steel sheet and plate, Ladish forged fittings, Kaiser aluminum, Alan Wood Clad metals and National Tube stainless piping, and the Cooper Alloy Foundry line will add stainless valves and fittings to Allied Metals services.

Ed Johnson Appointed Pump Consultant at Wilson-Snyder

Edward W. Johnson, former manager of the centrifugal pump department of National Transit Pump and Machine Company, Oil City, Penn., which was liquidated early this year, has been named consultant on centrifugal pumps at Wilson-Snyder Manufacturing Division of Oil Well Supply Company, Braddock, Penn.

Johnson

Johnson designed Types E-S and C-S chemical, processing and general service centrifugal pumps, ranging in size from 1 x 1½ x 6 inches to 6 x 8 x 10½ inches while employed by National Transit. Wilson-Snyder acquired this line early this year.

Johnson joined "Oilwell" in October, 1950. He spent seven years with Gulf Oil Company at its Port Arthur, Texas, refinery; five years with The Texas Company at the same site, as well as five years with National Transit Pump.

Cyanamid Promotes W. D. Thomas Technical Representative

Appointed technical representative of the Petroleum Chemicals Department, Industrial Chemicals Division of American Cyanamid Company, W. D. Thomas, Jr., will assemble and correlate technical information gained in the field for guidance of Cyanamid development programs. A graduate of Pennsylvania State College and Columbia University, Thomas joined Cyanamid in 1940 as a

member of the newly formed Petroleum Chemicals Laboratory at the Stamford, Conn., research laboratories.

J. B. Peeso, Jr., will succeed Thomas as group leader of the Petroleum Chemicals Laboratory at Stamford. Peeso, a petroleum engineer graduate of the Colorado School of Mines, joined the company in 1946.

Baldwin Joins Butler at Butler Industries, Beaumont

James F. Baldwin, former manager of Beaumont Iron Works, has joined Butler Industries at Beaumont, Texas. He teams with E. E. Butler in the company's new offices and Mill Depot at 355 South Fourth Street. Butler Industries handles the sale and distribution of condenser tubes for Wolverine Tube Division in the Beaumont area.

Baldwin

Butler

Dushane to Philadelphia As AMC Vice President

C. Benson Dushane, Jr., formerly manager of the Mid-West Sales Division of American Meter Company, has been elected vice president in charge of sales. Dushane is president of the Keokuk Gas Service Company, Iowa, a director of the Wisconsin Fuel and Light Company, Manitowoc, Wis., and of United Cities Utilities Company, Chicago. He is a member of the American Gas Association, the Western Society of Engineers, the Southern Gas Association, and past president of the Midwest Gas Association. He will make his new headquarters in Philadelphia.

Dushane

Parker Appliance Adds Two Industrial Sales Engineers

Raymond B. Jewett and M. L. Sheehan have been named by Parker Appliance Company, Cleveland, as industrial sales engineers.

Jewett will represent the company in Philadelphia and will serve eastern Pennsylvania, New Jersey, Delaware, Maryland and Virginia, in application engineering. Graduate of Massachusetts Institute of Technology, he had been a process service supervisor for Union Carbide & Carbon Corporation for five years.

Sheehan will headquarter in Dallas and will serve the south central states in application engineering.

Patterson Establishes Dolan As Baltimore District Manager

The newly established Baltimore office of The Patterson Foundry & Machine Company, East Liverpool, Ohio, will be headed by Patrick Dolan who has been named district manager. The Baltimore office is located at 1605 Court Square Building. Dolan has been a sales engineer at the East Liverpool office for many years.

Dolan

From the Baltimore office, Dolan will serve Maryland, Virginia, West Virginia and North Carolina, lending assistance in plant planning, making recommendations for complete processing units, and advising on selection of equipment for process requirement of every type.

Fox to Represent A. O. Smith

John Fox has been named representative of the A. O. Smith Welding Products Division in the greater St. Louis area. He was formerly manager of the Machinery and Welder Corporation.

New Laclede-Christy Officers

Laclede-Christy Company has elected Donald N. Watkins president of the company and chairman of the board of directors. Newly elected treasurer is Roy Erikson who joined Laclede recently after terminating his association with Ernst and Ernst, public accountants.

Edward Williams was elected comptroller and secretary. Williams formerly was associated with Price Waterhouse and Company.

R. V. Burnette Named Manager Of Rockwell Service Division

New service manager for Rockwell Manufacturing Company's Meter and Valve Division is R. V. Burnette whose new duties will be to establish repair procedures in factories and district warehouses. Burnette was employed by Standard Steel Car Company in Sharon, Pa., before joining the Pittsburgh Equitable Meter Company in 1926. He has been junior engineer and gas sales engineer in the Chicago district, and sales supervisor for Pittsburgh-DuBois Division of gas products for the Chicago, Columbus and Pittsburgh sales districts during the past 25 years.

Burnette

Marks 25 Years Service

Stanford M. Wagner, vice president in charge of sales for Ethyl Corporation, recently completed his 25th year with Ethyl Corporation, and his 35th year of service to the oil industry, having spent ten years with the firm now known as Esso Standard Oil Company. His first Ethyl assignment was to assist

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in the installation of the mixing plants used for treating gasoline with Ethyl antiknock compound. He was largely responsible for the introduction of Ethyl gasoline on the West Coast.

Worthington Division Appoints Reinking New Sales Manager

Former assistant sales manager A. F. Reinking, of the Steam Turbine Sales division of Worthington Pump and Machinery Corporation, has been named manager of that division. Reinking will make his headquarters at the Wellsville plant. He is a graduate of Rose Polytechnical Institute with an ME degree, and also completed the Worthington Student Training Course in 1927 before being assigned to the New York district office. In 1929 he joined the Moore Steam Turbine Corporation, but was again associated with Worthington when Moore was purchased by Worthington in 1936.

Reinking

Plibrico Adds Mobile Agency

Newly appointed distributor for the Plibrico Jointless Firebrick Company, Chicago, is the Gulf States Insulation Company, P. O. Box 1281, Mobile 7, Ala. As distributor, Gulf States will maintain a complete boiler setting and installation service.

Burgess-Manning Opens Dallas Sales Office

Burgess-Manning Company, manufacturers of industrial noise abating equipment and originators of the "snubbing" principles to reduce noise from engine exhausts and compression intakes and specialists in surge control of gas and airline piping, have opened engineering and sales facilities at 1203 Dragon Street, Dallas. R. L. Leadbetter, vice president, will head the Dallas branch; S. G. Paddock was named manager of sales and A. P. Gallagher assistant engineer.

In Chicago, an architectural products division for the new Burgess-Manning radiant ceiling and acousti-booths has been set up under direction of Dudley W. Day, vice president. Plants are located in Libertyville, Ill., and Ashippun, Wis.

O'Ryan and Cass Assigned to Allis-Chalmers Sales in SW

John J. O'Ryan and Norman S. Cass have been named sales representatives to Allis-Chalmers general machinery division offices in the Southwest.

O'Ryan, a civil engineering graduate of the University of Colorado, has been assigned to the Dallas district office. Cass, an industrial engineering graduate of Oklahoma A. & M. College, has been named to the Oklahoma City branch office. Both men joined the Allis-Chalmers organization in 1949 and have completed the company's graduate training course.

New Duraloy Office in Detroit

A Detroit sales office which will function as a direct sales branch will be opened by the Duraloy Company, Scottdale, Pa., under the management of W. D. Hazleton. The office is located at 805 New Center Building, Detroit. Duraloy produces high alloy static and centrifugal castings.

Carl Blom Elected Vice President Byron Jackson

Carl Blom, who joined Byron Jackson Company in 1924 and who became chief engineer of the pump division in 1940, has been elected vice president of the company. Blom was graduated from the Trondheim Institute of Technology, Trondheim, Norway, in 1922, specializing in hydraulic engineering, and served one year as instructor before emigrating to the U. S. He joined B-J as a pump design engineer.

Blom

Some of the projects to which he added his knowledge of pump design are the Grand Coulee Dam, the Colorado River Aqueduct, the 1067 mile oil line from the Persian Gulf to the Mediterranean, and the $90-million oil line extending from Edmonton, Canada, to Lake Superior, the A. T. & Santa Fe Railway Company at Grand Canyon where water is lifted 3150 feet to the rim of the canyon, etc.

Davenport Assigned Atlanta Sales Area by Owens-Illinois

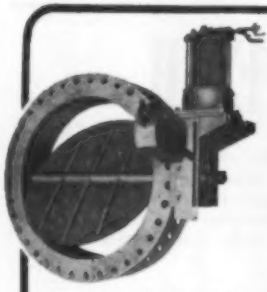
Reassignment by Owens-Illinois Glass Company sends Frank A. Davenport to Atlanta, Ga., as sales engineer for Kaylo Division. He replaces C. H. Ramien who is now acting as resident engineer at the Port Arthur, Texas, Kaylo installation. Ramien is waiting a broader assignment which has not been announced as yet.

Davenport

The Atlanta sales territory includes the North and South Carolinas, eastern Tennessee, Georgia, Alabama and Florida. Prior to his present position, Davenport sold United States Gypsum Company products in the southeast for eleven years and later managed his own building supply business. He joined Owens-Illinois in 1950.

Electron Microscope Study At Cornell from July 9-21

The Summer Laboratory course in "Techniques and Applications of the Electron Microscope" will be repeated this July 9 to July 21, at the College of Engineering, Cornell University, Ithaca, N. Y. The course is designed for research workers, institutional and industrial, who have recently entered the field of electron microscopy or who are now planning to undertake research problems involving applications of this



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instrument, according to T. R. Cuykendall, director of the Laboratory. Professor Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, is the man to contact for further inquiry.

Dr. Wetterstrom Joins Graver Research-Development Staff

Dr. Edwin Wetterstrom, who recently completed a Graver Research Fellowship at Purdue University, has joined the Research and Development staff of Graver Tank & Manufacturing Company, Inc., as analytical engineer. He will investigate new and independent lines of research in problems of the storage of volatile liquids.

Wetterstrom

At Purdue Dr. Wetterstrom conducted theoretical and experimental investigations related to practical problems in new Graver projects. He is interested in the design of pressure vessels and steel structures, and has written several articles on engineering design which have been published in professional journals. At one time a project engineer in charge of analysis for the Pressure Vessel Research Committee of the Welding Research Council, Dr. Wetterstrom was also on the development staff of the Continental Can Company, and has taught graduate engineering courses at Purdue.

Wilson Announces New Office

A new office to serve the Philadelphia, Camden and Trenton areas has been opened by Thomas C. Wilson, Inc., at 3147 North Broad Street, Philadelphia. Henry Steffans, sales engineer in Wilson's New York office since 1949, has been appointed manager of the new Philadelphia office.

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Jackson Engineering Named NRC Sales Representative

Jackson Engineering Company, 6144 Ferguson Drive, Los Angeles, has been appointed the sales representative for Southern California for the Heat Transfer Division of The National Radiator Company, Johnstown, Pa.

Jackson Engineering Company has specialized in engineering and manufacture of extended surface heat transfer apparatus in the oil and gas industries.

Esterline-Angus Promotes Lamb

Robert F. Lamb has been appointed sales and service engineer of Esterline-Angus recording instruments and associated products to replace Dean Thomas, who died recently. Lamb will move to Buffalo, N. Y.

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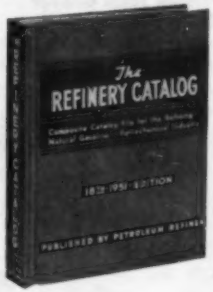

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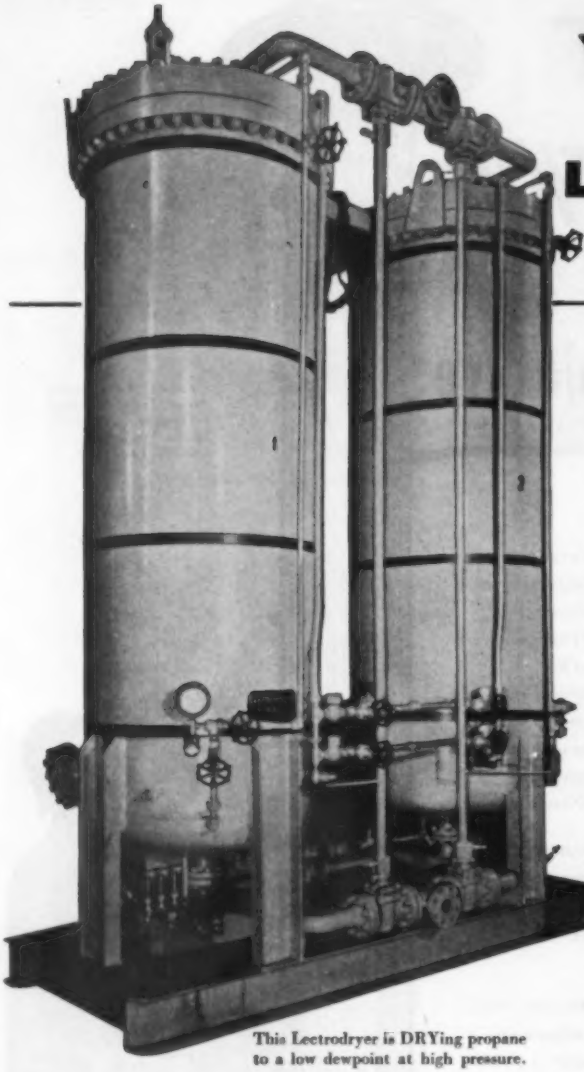

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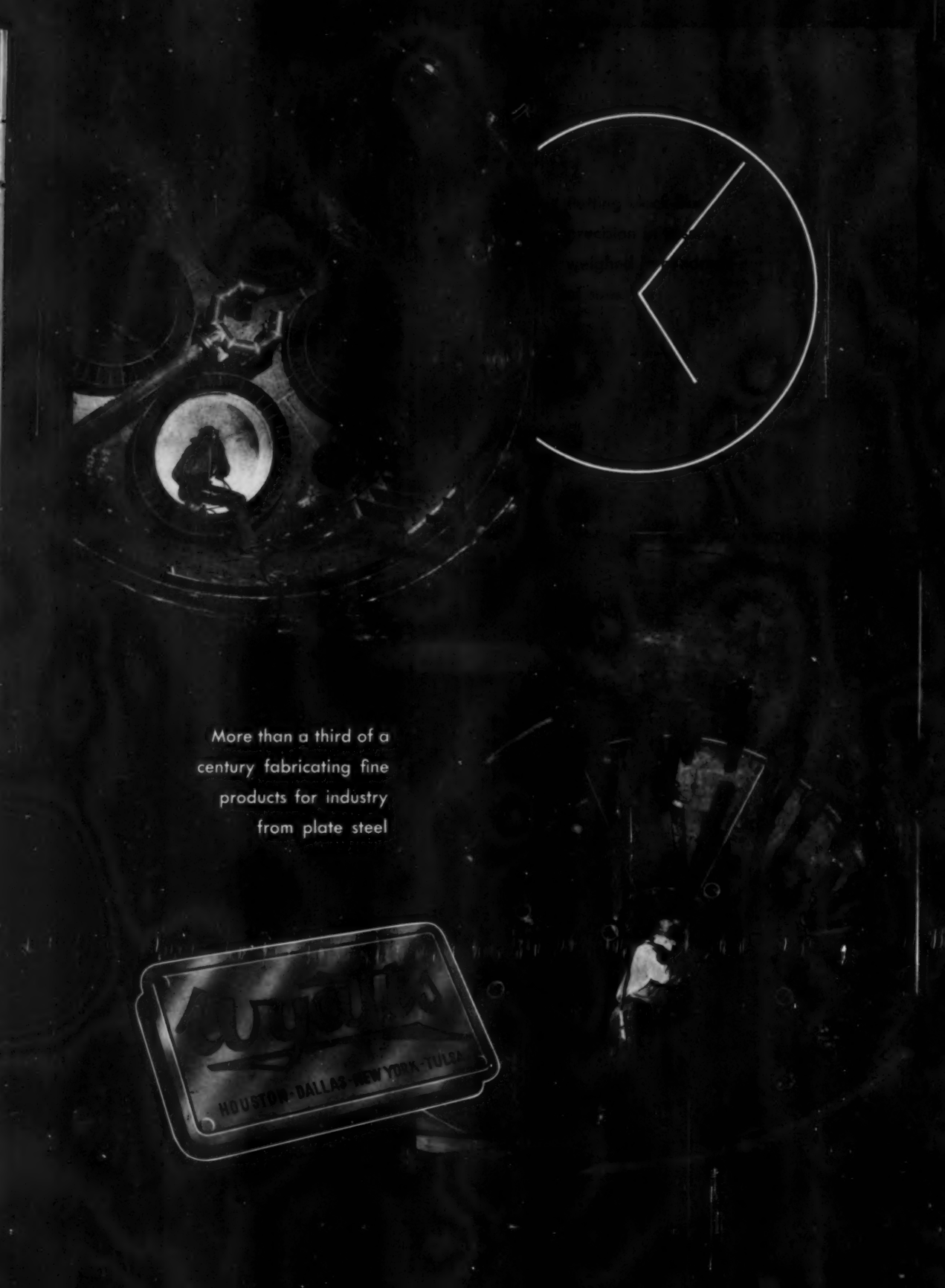
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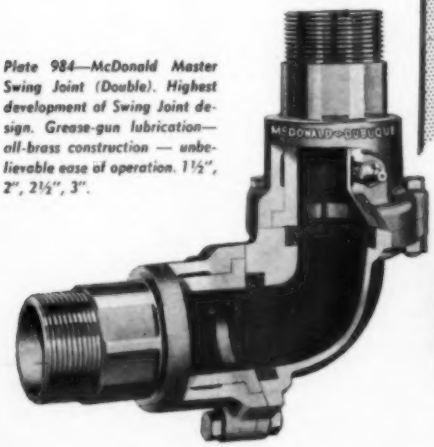

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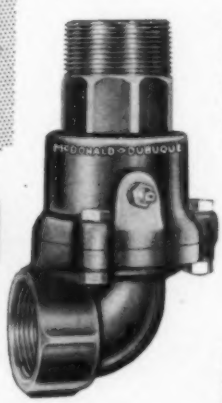

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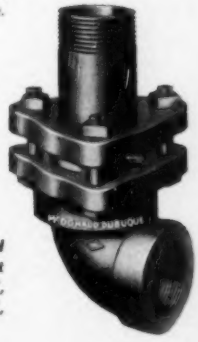

Plate 813—McDonald Standard Swing Joint (Single). ¾", 1", 1¼", 1½", 2", 2½", 3", 4", 6", 8", 10".